Australasian Transport Research Forum 2012 Proceedings
28 - 30 September 2012, Perth, Australia
Publication website: http://www.patrec.org/atrf.aspx

Analysis of Child Diaries – Can GPS Traces of Parents Movements Provide Sufficient Travel Data for Children?

Peter Stopher, Christine Prasad

Institute of Transport and Logistics Studies, The University of Sydney

Email for correspondence: peter.stopher@sydney.edu.au

Abstract

Global Positioning System (GPS) devices are moving into the mainstream for undertaking household travel surveys. However, in all applications to date, it has been decided to give GPS devices only to household members above a certain age (generally in the range of 12 to 14 years). Although some experiments have been done where GPS devices are provided to younger children, this has been in the context of special studies and not a broad household travel survey. In a recent effort in the USA, a GPS-only household travel survey was conducted on households in the Greater Cincinnati area. GPS devices were provided to all household members in sampled households over the age of 12 years. Child diaries were, however, provided for each child in a sampled household 12 years old or younger and a parent was asked to complete summary travel information for each such child for a 24-hour period. In this paper, an analysis is reported of these child diaries, to determine to what extent a child's travel can be inferred from the parents' travel and from a knowledge of the school attended by the child, and what travel information is lost by not providing a GPS device to each young child. This has important implications for the potential for GPS to replace conventional diaries in household travel surveys.

1. Introduction and Background

Starting in the mid-1990s (Wagner, 1997), the use of Global Positioning System (GPS) devices to record personal travel has been the subject of increasing interest in the transport profession. During the early part of the 21st century, GPS devices were used principally to assess the validity of conventional diary surveys (Stopher, 2009) and also to evaluate voluntary travel behaviour change projects (Stopher et al., 2009). Starting in 2009, GPS devices have begun to be used as a complete replacement for travel diaries (Giaimo et al., 2009; Stopher and Wargelin, 2011; Oliviera, 2011). A concern in using GPS devices to measure travel has been the issue of the minimum age of household members who should be considered eligible to carry GPS devices. Ethical considerations suggest that great care needs to be taken in setting a minimum age for a child to carry a GPS device around with them. Also, concerns about how a GPS device will be handled by a child arises as a secondary issue. For example, it is imperative, for a GPS device to provide accurate measurement of a person's travel, that the device be carried by the person to whom it is assigned for the entire time for which measurement of travel is desired. It seems likely that, when a small sample is drawn from a fairly large population, a child assigned a GPS device might be the only child in a class at school that has a device. One can readily imagine this child showing the device to her or his friends, and lending it to one of her or his friends to carry around for part of the day (or even an entire day, when the measurement period is multiple days). One can also readily imagine another child desiring to experiment with the device to see under what circumstances it continues to work and under what circumstances it fails to work, such as in a puddle, or under a pile of rubbish. These and other issues could easily emerge as significant issues if devices are provided to quite young children.

It is true that there have been some experiments with GPS that have involved children of quite young ages carrying devices (e.g., Mackett et al., 2007; Elgethun et al., 2007). However, in these cases, the sample was drawn from children in particular classes in a specific school, so the issue of sharing devices probably did not arise, and experimenting with the devices in unacceptable ways was not reported as a major issue. The problem in a large-scale household travel survey is that there will be much more of a uniqueness problem for a child equipped with a GPS device.

As a result of these concerns and also ethical concerns about equipping very young children with GPS devices, the decision is usually made to restrict the assignment of GPS devices to children over the age of somewhere between 12 and 14 years. In the study used in this paper, the decision was to restrict the assignment of GPS devices to children over the age of 12.

In conventional surveys of household travel, it is customary to collect data on the travel movements of either everyone in the household over the age of 5, or everyone regardless of age. By restricting GPS data collection to children over the age of 12 or 14, there is clearly a potential loss of data for each household with younger children. Little has been written about the issue of a minimum age for collecting conventional diary data. It has generally been assumed that children under age 5 will always travel with a parent, so that measurement of the parent's travel will actually provide measurement of a very young child's travel. One of the arguments for changing the convention to measuring the travel of everyone in the household regardless of age is that, in an age in which both parents work in many households, the very young child may now travel with a babysitter, or otherwise may travel independently of the parents at some times of the day. This assumption has actually not been tested, to the best of our knowledge. Nevertheless, it is the issue that surrounds whether or not all members in a household should provide travel data, or only those over the age of 5, which is the age in most countries at which a child first enters formal education and may be expected to undertake some travel without a parent present (Stopher and Jones, 2003).

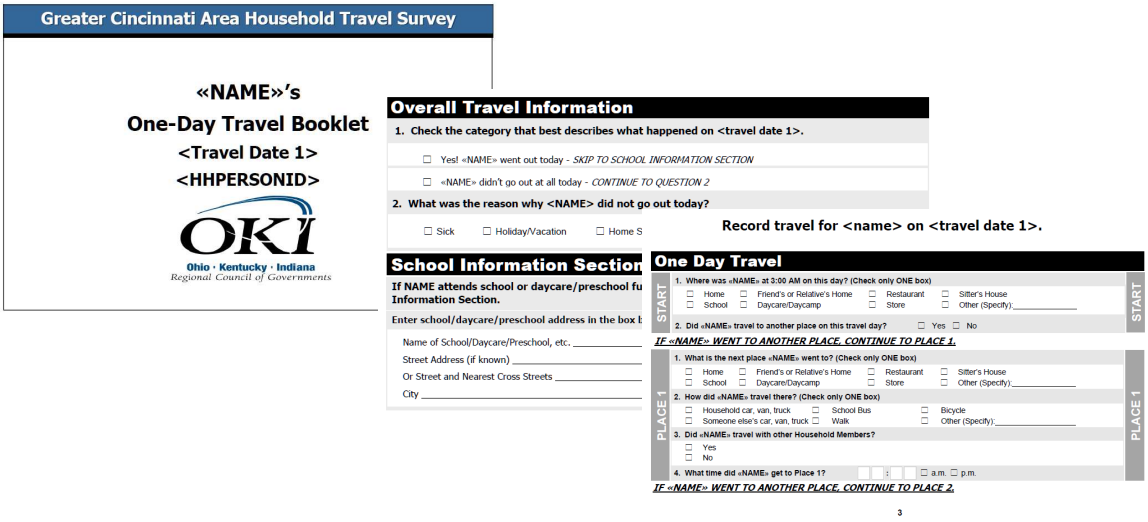
Based on this discussion of a minimum age for recording travel, it is clear that setting a minimum age of 12 to 14 years for carrying a GPS device is likely to lose some significant amount of travel from households with children under the minimum age. However, it is unclear whether or not such travel can be inferred from the travel of the older members of the household, and from knowledge of where the schools are located that younger children from the household attend. To test this assumption, it would be necessary to collect GPS data from households, with the restriction on children carrying devices, and to devise some other method for recording the travel of those children who are too young to carry a GPS device. It could then be investigated as to how much travel is lost from the records by the age restriction.

2. The Greater Cincinnati Area Household Travel Survey

2.1 The survey

An opportunity to investigate the potential loss of data arose in connection with the Greater Cincinnati Area Household Travel Survey (GCAHTS) conducted during 2009-2010 (Giaimo et al., 2009; Stopher et al., 2011). This survey involved collecting data from more than 2000 households using GPS devices. The GPS devices were to be used by eligible household members for a period of three days. In this survey, the decision was made to restrict the assignment of GPS devices to household members over the age of 12. However, for household members under this minimum age, a child diary was provided. This diary was designed to be filled out by a parent for each child under the age of 13 for one of the days for which GPS data were collected from other household members. The child diary is shown in Figure 1.

Figure 1: Child Diary Pages (Part)



It was designed to collect data for a single day and to do so in a very abbreviated form, so as not to be unduly burdensome. Only limited information was to be recorded about one day of travel for each child in the household under the age of 13. The survey sample consisted of 2,796 households, of which 2,059 households were deemed complete for GPS measurement. From the sample of 2,059 households, 574 households reportedly had children present. Out of these 580 households, 413 households (71.2 percent) with 728 children (73.3 percent) were sent child diaries. The remaining 167 households had children who were older than 12 years of age. Child diaries were returned by 310 households with a total of 560 children. One of these households did not have corresponding GPS data, because the one adult in that household claimed not to have travelled outside the home at all during the GPS measurement period. The response rate on the child diaries was, therefore, 75.1 percent of households, and 76.9 percent of children, suggesting that households with fewer children were less inclined to complete the survey.

2.2 Socio-demographics of the sample

The total sample of households comprised 2,059 households that completed the GPS task as prescribed by the Ohio Department of Transportation. Of these households, 574 (27.9 percent) had a child or children present, 1,025 households were adult only households, 377 were households of retired persons, and 83 were adult student households. Table 1 shows a comparison of statistics for all households in the region, households that completed the GPS survey, households that had a child or children under the age of 13 present, and households that completed child diaries.

From Table 1, it can be seen that the sample itself is reasonably representative of the region (especially bearing in mind that the census data are from 2000, whereas the survey was performed in 2009-10). Comparisons of the households with children and those completing child diaries shows, as one would expect, more 2 plus persons in households, and more 2-worker households than the general population. Both of these are expected results. It is also apparent that there is no strong non-response bias on household size or workers in the household between the households that completed child diaries and households that were sent child diaries. There is a small decrease in the proportion of non-worker households in those that returned diaries and an even smaller decrease in households with three or more workers. Also, not surprisingly, there are fewer non-car-owning households among the households with children than in the general population, and substantially more households with 2 cars. This is maintained among the households that completed child diaries, with a slight decrease in households with no cars and one car, and a further increase in households

with 2 cars. Other than this, Table 1 does not show any marked differences between the samples.

Table 1: Comparison of Demographic Characteristics for Survey and Child Diary Households

Demographic	Region (2000 Census)	GPS Survey	Households with Children	Households Completing Child Diaries
Household Size				
1 Person	27.3%	669 (32.5%)	0 (0.0%)	0 (0.0%)
2 Persons	32.0%	696 (33.8%)	25 (6.1%)	14 (4.5%)
3 Persons	16.6%	278 (13.5%)	102 (24.7%)	77 (24.8%)
4+ Persons	24.1%	416 (20.2%)	286 (69.2%)	219 (70.7%)
TOTAL	100.0%	2,059 (100.0%)	413 (100.0%)	310 (100.0%)
Number of Vehicles				
0 Vehicles	9.7%	91 (4.4%)	9 (2.2%)	3 (1.0%)
1 Vehicle	32.3%	676 (32.8%)	63 (15.3%)	44 (14.2%)
2 Vehicles	38.8%	809 (39.3%)	235 (56.9%)	191 (61.6%)
3+ Vehicles	19.2%	483 (23.5%)	106 (25.7%)	72 (23.2%)
TOTAL	100.0%	2,059 (100.0%)	413 (100.0%)	310 (100.0%)
Number of Workers				
0 Workers	24.0%	578 (28.0%)	42 (10.1%)	23 (7.5%)
1 Worker	37.4%	708 (34.4%)	128 (31.0%)	103 (33.2%)
2 Workers	31.3%	638 (31.0%)	215 (52.1%)	166 (53.5%)
3+ Workers	7.3%	135 (6.6%)	28 (6.8%)	18 (5.8%)
TOTAL	100.0%	2,059 (100.0%)	413 (100.0%)	310 (100.0%)

In the households with children under the age of 13, Table 2 shows some statistics relating to the education of the children, and the numbers of children by age, and by number in the household. Comparing between households that were sent child diaries (i.e., those with children under 13 years of age) and those that returned child diaries, it can be seen that there are only very slight differences in the distributions of each of these statistics. Not surprisingly, those households that did not indicate current schooling were also more likely not to return child diaries. This led to a slight decrease in 1 and 2 year olds in the age distribution. As noted earlier, however, there is also a slight bias against households with one child completing child diaries, with almost complete responses from those with 4, 5, and 6 children in the household. This is a bit surprising, considering that these larger families had much more work to do to complete the diaries.

Overall, Tables 1 and 2 do not show any evidence of biases in the completion of child diaries. Therefore, it seems reasonable to assume that the child diaries were completed by a representative sample of the population of households with children, at least insofar as these limited demographics are able to show. Given this, the analysis of the results of the child diaries are of substantial interest to determine whether or not children's travel can be reasonably easily factored from GPS records of travel by household members over the age of 12.

Table 2: Statistics for Households with Children under the Age of 13

Statistic	Households with Children Under 13	Households Completing Child Diaries
Children per Household		
1	187 (45.3%)	134 (43.2%)
2	155 (37.5%)	119 (38.4%)
3	57 (13.8%)	44 (14.2%)
4	11 (2.7%)	10 (3.2%)
5	2 (0.5%)	2 (0.6%)
6	1 (0.2%)	1 (0.3%)
TOTAL	413 (100.0%)	310 (100.0%)
Ages of Children		
0	14 (1.9%)	13 (2.3%)
1	76 (10.4%)	55 (9.8%)
2	51 (7.0%)	35 (6.3%)
3	45 (6.2%)	35 (6.3%)
4	47 (6.5%)	37 (6.6%)
5	68 (9.3%)	53 (9.5%)
6	56 (7.7%)	44 (7.9%)
7	47 (6.5%)	37 (6.6%)
8	70 (9.6%)	53 (9.5%)
9	71 (9.8%)	57 (10.2%)
10	57 (7.8%)	46 (8.2%)
11	57 (7.8%)	45 (8.0%)
12	69 (9.5%)	50 (8.9%)
TOTAL	728 (100.0%)	560 (100.0%)
Schooling		
Not in School	2 (0.3%)	1 (0.2%)
Daycare/Preschool	128 (17.6%)	103 (18.4%)
K-12	465 (63.9%)	363 (64.8%)
Other	2 (0.3%)	2 (0.4%)
Refused/No Answer	131 (18.0%)	91 (16.3%)
TOTAL	728 (100.0%)	560 (100.0%)

3. Analysis of Child Diaries

3.1 Overall Analysis

Out of the 310 households who completed child diaries, one household did not have any GPS travel on the diary day. From the 309 households with child diary trips and GPS data, child diary trips for a subsample of 130 households were compared to GPS data from the same households. The reason that a larger number have not been compared is a result of the intensity of the work required, where careful inspection has to be made of all the GPS trips recorded over three to five days by each GPS-equipped person against the results of the child diaries for the same household. Of the 130 households, 50.4 percent had one child, 35.1 percent had two children, 13.0 percent had 3 children, and 1.5 percent had 4 children. No households had more than four children. Comparing these statistics to the overall statistics in Table 2, it is apparent that there is no substantial bias on number of children among the 130 households that were analysed in depth. Within this subsample, there was a total of 217 children with 693 trips, averaging 5.33 trips per household and 3.19 trips per child.

From this subsample of 130 households, 546 trips were claimed to have been made with other household members while 143 trips were claimed not to have been made with other household members (there were 4 trips where no information was provided on whether or

not a household member accompanied the child). There were 20 households containing 28 children, making 60 trips where no household member accompanied the child on any trip. The trip rates for these households was therefore 3.00 trips per household, and 2.14 trips per child. There were 110 households with 188 children who made one or more trips in the company of another household member. These children made a total of 633 trips. The trip rate for children who claimed to have travelled with other members of their household was 5.75 trips per household and 3.37 trips per child.

Child diaries only collected information for one day of travel, generally the first day. Information collected included place of start and destination, mode of travel, arrival time at destination, and whether a person travelled with another household member. The date of travel was not collected. This created some issues in the matching process. Although household members were supposed to start using their GPS devices the day after receiving them, they did not always do so. Also, the household was supposed to fill out the child diaries for the first day of the GPS survey. Again, it became apparent on analysing the results that this was also not always the case. Therefore, in matching, it was necessary to search among all persons in the household who had received GPS devices and on all days of travel from the GPS devices, in order to find a match to the child diary data.

It was also noteworthy that, according to the diary data, a number of children went to school in the morning and never returned home on that day, while others came home from school in the afternoon, but had not gone to school on that day. Apart from trips to and from school, there were also a few other cases where only one trip was reported for a child on the diary day. A total of 14 children had only one trip reported in their diaries, with 4 of these being unaccompanied, 9 accompanied, and one providing no information on whether or not the trip was accompanied.

3.2 In-depth Analysis

Comparisons between GPS records and child diary records were made by comparing the time of travel, that is, the arrival time given in child diary records compared to the arrival time recorded by GPS devices of household members. Table 3 shows the numbers of trips that matched or did not match for arrival time in the diary.

Table 3: Analysis of Child Diary Match on Time of Trip Start

Time match	All trips		Trips made with HH members	
	Frequency	Percent	Frequency	Percent
No match	184	26.6%	114	20.9%
Definite match (within 15 mins)	274	39.5%	251	46.0%
Possible match (over 15 mins but within 30 mins)	69	10.0%	61	11.2%
Possible match (over 30 mins but within 1 hour)	48	6.9%	44	8.1%
Walk Trip	24	3.5%	5	0.9%
School Bus Trip	19	2.7%	7	1.3%
No GPS Data	75	10.8%	64	11.7%
Total	693	100%	546	100.0%

Among the reasons for no match on time were: times being misreported in the child diary, such as AM or PM being indicated incorrectly, or times not matching by more than 1 hour; missing time values in the child diary; and missing GPS travel times. These causes of missing values are actually quite common in prompted recall surveys as well, so are not

particularly surprising in this instance. Approximately 27 percent of all child diary trips analysed and 21 percent of child diary trips with a household member accompanying them showed no match, meaning that either times were different by more than 1 hour, or that the times were missing in either the GPS or the diary record. However, it is notable that 56.4 percent of all trips reported in the child diaries showed a match within one hour, while 65.3 percent of trips reported in child diaries with an accompanying household member were also reported within 1 hour of the GPS travel times. Walk and school bus trips are noted separately in Table 3, partly to indicate the incidence of these in the child population, and partly because, if a household member accompanied the child, this was more often than not another child without a GPS device, so that the data could not be matched to GPS results.

Table 4 shows the results of the analysis of the origin location of the children's trips. It is symptomatic of diary data that people often do not self-report origin and destination data very well. In addition, with GPS data, if the household location or the school were incorrectly geocoded, or there was a cold start problem with the GPS device, then there will not be a match on the origin. A cold start problem occurs when the device requires some seconds to establish its position and as a result starts recording the travel more than 100 metres away from the true start. This will result in an incorrect identification of the origin starting point. Another problem can arise with the school location. The school will have been coded to a specific point, usually based on the street address of the school. If the school property is large, and especially if the pick-up or drop-off point for students is on a different street than the official street address, then the GPS record may not identify the school correctly as the origin of a trip. These same difficulties can arise with the destination, as discussed for Table 5, below. However, it is a good result that nearly 57 percent of all child trips and over 59 percent of accompanied child trips appear to match or potentially match.

Table 4: Analysis of Child Diary Match on Origin Location

Origin Match	All trips		Trips made with HH members	
	Frequency	Percent	Frequency	Percent
No match	267	43.2%	223	40.8%
Definite Match	223	36.1%	204	37.4%
Possible Match (New place)	128	20.7%	119	21.8%
Total	693	100%	546	100.0%

Table 5 shows very similar results for destination matching as were obtained for origin matching. For trips made with household members present, the rate of matching is almost identical to that for origins. The same problems arise with both the diary data and the GPS processed data in making destination matches as have been noted for the origins. Again, however, approximately 60 percent of all destination locations for which a household member travelled with the child show a definite or possible match, with about 57 percent of all child trips showing a potential match.

Table 5: Analysis of Child Diary Match on Destination Location

Destination Match	All trips		Trips made with HH members	
	Frequency	Percent	Frequency	Percent
No match	265	42.9%	220	40.3%
Definite Match	223	36.1%	199	36.4%
Possible Match (New place)	128	20.7%	127	23.3%
Total	618	100%	546	100.0%

Table 6 shows the results of the matching analysis for mode. Again, as with origin and destination, the mode from the GPS data is a result of processing the GPS data and can be in error. In addition, there were a significant number of occasions on which respondents did not provide a mode in the child diary. In this case, a possible match would arise only if the diary indicated no mode and the GPS indicated the mode. Hence, there are very few cases that arise where a possible match was found. One of the reasons for the rather high lack of match for mode is also the number of instances where the diary contained no indication of mode.

Table 6: Analysis of Child Diary Match on Mode of Travel

Mode Match	All trips		Trips made with HH members	
	Frequency	Percent	Frequency	Percent
No match	293	47.4%	240	44.0%
Definite Match	309	50.0%	293	53.7%
Possible Match	16	2.6%	13	2.4%
Total	618	100%	546	100.0%

As is expected, in all four cases – time, origin, destination, and mode – the percentage of no match is lower for the accompanied trips than for all trips. In fact, the only reason why there are a few more instances of a match for trips without an accompanying household member to trips with an accompanying household member is because the diaries sometimes were blank on whether or not there was an accompanying household member. Thus, there are 35 more trips that show a possible or definite match on time, 28 on origin, 25 on destination, and 19 on mode for all trips than for trips where it was indicated that a household member accompanied the child. All of these are cases where the diary was silent on accompanying persons, but where analysis found a match.

There were 55 trips (10.1 percent) with an accompanying person and 57 trips in total (8.2%) that matched on all of the four attributes: time, origin, destination, and mode. Only two of these matched trips were not claimed to have been made with a household member. If the definition for matching is relaxed to permit possible matches (within 15 minutes for time) as well as definite matches, then these numbers increase to 219 (40.1 percent) and 229 (33.0 percent) for accompanied and all trips respectively. This indicates that there is a relatively high proportion of trips that were reported in the child diaries that can be matched definitely or possibly with those recorded by the GPS, notwithstanding issues with diary completion and inaccuracies in the GPS processing software.

The fact that 78.8 percent (546 out of 693) of child diary trips were claimed to be made accompanied by another household member indicates that the loss of data from children of 12 years of age and under not carrying a GPS is potentially quite small. As noted earlier, the trip rates for children who made all of their trips on the diary day without another household member were comparatively much lower than the trip rates for children who travelled with other household members. However, the child diary data show a number of problems of self-report diary data, which resulted in a failure to obtain matches more than about 55 percent of the time. However, it is notable that each of the trip, origin, destination, and mode of travel were definitely or probably a match approximately 55 percent of the time (60 to 65 percent of those trips that were with another household member). It is disappointing, but not surprising, given the general problems associated with diary data and self-reporting, that approximately 35 percent of the trips with other household members provided no match on at least one of the four attributes.

3.3 Factoring

The question then must be raised as to whether these results could lead to any sort of factoring for the trips not reported by GPS for children 12 years old and under. First, it might be suggested that the number of trips for children under 12 years old could be estimated by using the daily trip rates reported at the outset of this analysis, namely about 3.2 trips per child per day. Applying this trip rate to the 217 children analysed in this paper would produce an estimate of 694 trips by children, which is only one trip more than the number actually claimed. This figure is probably slightly low, since it was noted earlier that 14 children had only one trip reported, where almost certainly at least two trips took place, so there is a clear undercount of trips from the diaries. Of the child trips, it would appear that about 21 percent were made without an accompanying household member and would be predominantly either school bus or walk trips. This suggests that a simple factoring of about 0.7 trips per child per day should be assumed to be by school bus or walking. Further examination of the data suggests that about 0.3 trips per child could be assumed to be by school bus and 0.4 trips per child by walking (these being figures specific for the US and possibly specific to Cincinnati, Ohio only). Almost all of the remaining 2.5 trips per child per day would appear to be trips made in a household car.

In total, 531 trips had one end at home, while 310 of the 693 trips (44.7 percent) made by these 217 children were either to school (156) or from school (154). The second most frequent purpose was to travel to or from a store (132 trip ends), while the third was for recreational purposes (106 trip ends). Travel to or from a friend or relative, and to or from daycare were the only other fairly frequent purposes, with 74 and 66 trip ends respectively. It was also noted that all of the walk trips involved a trip either to or from school. Therefore, it can be assumed that 1.43 trips per child per day are to or from school, out of which 0.3 trips are by school bus, 0.4 trips are by walking, and the remaining 0.73 trips are almost entirely by household car.

4. Conclusions

The use of child diaries for one day of travel and abbreviated reporting has proved useful to assess the amount of data that may be missed from children who are considered too young to carry a GPS device in a GPS-only survey of household travel. In conducting this survey with child diaries, there are no clear biases present from households that responded and households that did not respond to the child diaries. Therefore, it seems reasonable to assume that the results obtained from the child diaries are reasonably representative of households with younger children. Based on an in-depth analysis of the contents of the child diaries, a number of conclusions can be drawn.

First, even these abbreviated child diaries suffer from most of the self-report errors that have been encountered over the past few years as GPS has been used to validate diary data and

to determine the extent to which diary data are reported accurately. Errors include omitted trips, incorrect identification of purpose, mode, and most especially time of travel, and absence of information on one or more attribute of the travel. Second, it appears that the vast majority of travel by children 12 years old and under is made in the company of other household members. This means that if GPS data are used primarily to determine vehicle movements, it is likely that they are doing a reasonably complete job. In those instances where children travelled with no accompanying household member, the vast majority of these trips were made by school bus or walking. Children who travelled entirely without an accompanying household member generally made more than 50 percent fewer trips (2.1 trips per child per day) than those who travelled with accompanying household members (3.4 trips per child per day).

Third, it appears that approximately 3.2 trips per day are made on average by children aged 12 years and under. Of these about 1.43 trips per day per child are trips to or from school, with 0.4 of these trips being made by walking, and 0.3 by school bus. The remaining trips are made almost entirely by household vehicle. Because a large majority of trips made by children of 12 years and under are made in the company of a household member, household vehicle trip rates determined from a GPS survey will be largely correct, without any significant factoring. However, to estimate total person trip rates correctly, it is recommended that approximately 3.2 trips per child per day be added to each household with children under the age of 13. Further analysis of the child diary data could potentially provide different factors for children of different age groups.

References

Elgethun, K Yost, M G Fitzpatrick, C Nyerges T and Fenske R (2007) Comparison of global positioning system (GPS) tracking and parent-report diaries to characterize children's time – location patterns, *Journal of Exposure Science and Environmental Epidemiology*, 17, 196 - 206

Giaimo, G Andersen, R Rohne, A Wargelin, L Stopher, P Tierney, K and O'Connor, S (2009) *The Greater Cincinnati Area Large-Scale (100%) GPS-Based Household Travel Survey*, paper presented to the Transportation Planning Applications Conference, Houston

Mackett, R Brown, B Gong, Y Kitazawa, K and Paskins, J (2007) Children's Independent Movement in the Local Environment, *Built Environment*, 33 (4), 454-468

Oliviera, S M G Vovsha, P Wold, J Birotker, Y Givon, D and Paasche, J (2011) Global Positioning System–Assisted Prompted Recall Household Travel Survey to Support Development of Advanced Travel Model in Jerusalem, Israel, *Transportation Research Record* 2246, 16-23

Stopher, P R and Jones, P M (2003) Developing Standards of Transport Survey Quality, pp 1-38 in Stopher, P R and Jones, P M (eds), *Transport Survey Quality and Innovation*, Pergamon Press, Oxford

Stopher, P R (2009) Collecting and Processing Data from Mobile Technologies, pp 361 - 391 in Bonnel, P Lee-Gosselin, M Zmud, J and Madre, J-L (eds) *Transport Survey Methods: Keeping Up With a Changing World*, Emerald

Stopher, P R Zhang, Y Zhang, J and Halling, B (2009) Results of an Evaluation of TravelSmart in South Australia, paper presented to the *32nd Australasian Transport Research Forum*, Auckland, September

Stopher, P R Prasad, C Wargelin, L and Minser, J (2011) Conducting a GPS-Only Household Travel Survey, paper submitted to the *International Conference on Travel Survey Methods,* Chile, November 2011

Wagner, D P (1997) *Lexington Area Travel Data Collection Test: GPS for Personal Travel Surveys*, Final Report for OHIM, OTA, and FHWA, US Department of Transportation, Washington, DC