Trip Rates, Non-Mobility, and Response Rate: Measures to Evaluate the Quality of a Travel Survey

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1 Introduction

A mainstay of much analysis in transport planning is the household travel survey, along with a variety of other surveys, that together provide an information base for policy development, modelling, and the development and testing of alternative courses of action. An important issue in using these sources of information is that of assessing the quality of the survey that produced the information. Reading the transport planning literature, it becomes fairly clear that the majority of the time, the only measure of quality that is provided is the response rate for the survey, and even the response rate is calculated in almost as many different ways as there are surveys in existence. The response rate is not, however, an adequate measure of the quality of a survey. There will be cases where a high response rate is obtained, but the data quality is very poor, and the reverse can also be true. Furthermore, there is a need for a clear and consistent method by which to compute response rates, so that planners and analysts can be sure that they are comparing like with like.

In a recent research project for the US National Cooperative Highway Research Program (NCHRP, 2006), the Institute of Transport and Logistics Studies addressed these issues. First, we investigated what might be the best method of computing response rates. Second, we turned our attention to other measures that might be used to assess quality, and proposed several. Two that are directly applicable to household travel surveys conducted by any of the available methods are trip rates and non-mobility. In this paper, we provide a review of the research into these measures of quality and then illustrate their use in a particular survey, carried out in New South Wales.

2 Response rates

Proper calculation of response rates is important because response rates are used by analysts to assess survey quality. Higher response rates are usually desired to reduce the likely incidence of non-response bias. For example, in household travel surveys, it has been found that non-respondents have different travel and demographic characteristics to those of respondents (DeHeer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000). Hence, the resulting data set is biased – i.e., it is not representative of the general population.

Response rates are calculated by analysts to observe the overall quality of the completed survey (Beerten *et al.,* 2000; Lynn *et al.,* 2001). However, the response rate to a survey is only one survey quality indicator, therefore, one cannot assume that a high response rate necessarily indicates good quality data. Although response rates are not the only indicators of survey quality, they are important indicators that are readily quoted by survey practitioners, reinforcing the need for this item to be standardised.

Response rates have become more of an issue because they have been falling over recent years (Ezzati-Rice *et al.,* 1999; Dillman and Carley-Baxter, 2000; Dillman *et al.,* 2001; Kalfs and van Evert, 2003, Australian Market and Social Research Society, 2000). Hence, most travel survey practitioners would strive to obtain higher response rates to travel surveys. However, due to the inconsistency of the definition of response rates often quoted in travel surveys, it is difficult to state explicitly that declining response rates are the result of less people willing to participate in surveys or are attributable to the calculation of response rates. It is most likely to be a combination of the two. This then leads to the problem of incomparability: hence, the need for a standardized method to calculate response rates.

Until recently, the Council of American Survey Research Organizations, CASRO, was the only organization in marketing and related areas with its own method for calculating response rates. However, some years after the development of the CASRO method, the American Association of Public Opinion Research (AAPOR) developed another method for calculating response rates. Both the CASRO and AAPOR formulas are commonly used by survey practitioners. For example, the Advertising Research Council (ARC), Council of Marketing Opinion Research (CMOR) and Marketing Research Association (MRA) use a modified version of the AAPOR method for calculating response rates (CMOR, 1999), although the World Association of Opinion and Marketing Research Professionals (ESOMAR) does not have its own method for calculating response rates.

Before discussing how to estimate a response rate, it is important to understand the main dispositions for sampling units in a survey. A sample can be divided first into two groups. The first group is called the 'eligibility known' group, and the second group is called the 'eligibility unknown' group. The 'eligibility known' group consists of all of those sample units that have been contacted successfully, and a determination made that the unit is either an eligible member of the population or is ineligible. If we are discussing a household travel survey, for example, and the sample units are telephone numbers, an eligible telephone number is one that is determined to belong to a household that meets whatever eligibility criteria have been established for proceeding with the survey, such as location within the study area, being a number of a residential household, and where there is a least one person able to speak and read one of the languages in which the survey is being conducted. If the telephone number is found to belong to a business, or is not in service, or belongs to a public telephone, then the number is ineligible. Hence, the eligibility known group divides into two further subgroups: the eligible and ineligible. In the first group and subgroup, there is a further sub-grouping into respondents and non-respondents. This is shown diagrammatically in Figure 1. The 'eligibility unknown' group comprises all sample units whose eligibility for the travel survey is never established. These would include, in this example, telephone numbers where an answer is never obtained.

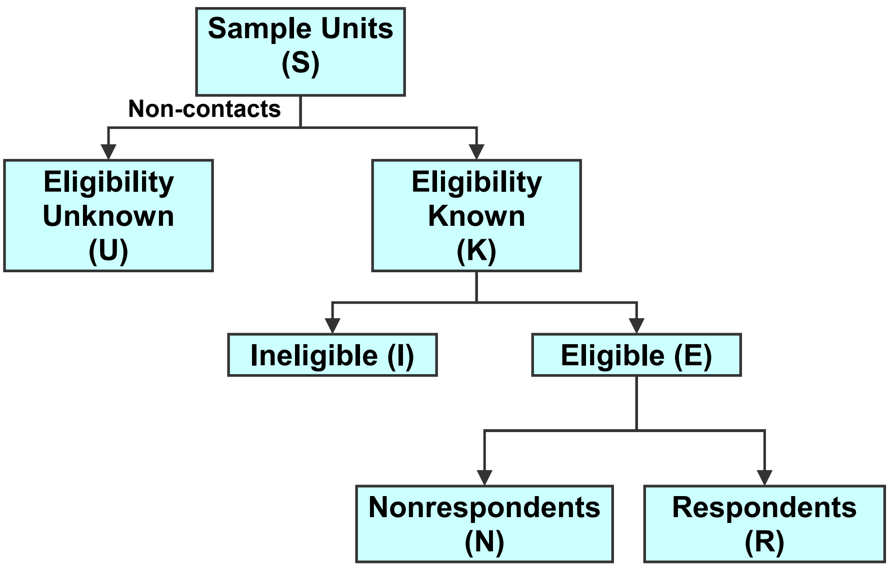

Figure 1: Sample Grouping By Eligibility

In many cases, in transportation surveys, the response rate is presented as the respondents divided by the eligible sample units (i.e., R/E). This is actually the cooperation rate (COOP1), defined by the AAPOR (2004). By definition, the COOP1 rate ignores the portion of the sample that have not been contacted successfully, and within which there is presumably a number of eligible sample units.

Other possible definitions of response rate might include the number of respondents divided by the total sample units (R/S), which would provide a response rate that is generally considered too low. Many of the eligibility unknown units may prove to be ineligible, so that including them as though they are eligible produces an incorrect estimate of response rate. Another, also generally erroneous calculation would be the respondents divided by the eligibility known units (R/K). In one paper consulted, this formula for the calculation of response rates was used (Singer *et al.,* 2000). The result was an underestimation of response rates because all known ineligible sample units were included in the calculation (denominator). The problem is accentuated if many of the attempted contacts are ineligible sample units.

2.1 Estimating response rates

The response rate is simply defined as the ratio of the number of completed interviews divided by the number of eligible sample units, where eligible sample units are the sample units that have met certain eligibility criteria (CASRO, 1982; CMOR, 1999; Ezzati-Rice *et al.,* 1999; Richardson and Meyburg, 2003; AAPOR, 2004). The principal issue, then, is what we do about the group of sampling units that fall into the category of 'eligibility unknown'.

The main difference between the CASRO and AAPOR methods lies in the estimation of an eligibility rate for sample units of unknown eligibility. Both methods agree that a proportion of the eligibility unknown units would be eligible, and should be included in the estimation of the response rate, but the two do not agree on how to estimate this. The CASRO method is quite simple. It assumes that the eligibility rate for the eligibility unknown group is the same as that in the eligibility known group. Referring to Figure 1, this would mean that the eligibility rate for the CASRO method is simply E/K. Applying this to the unknown eligibility group will provide an estimate of the number of eligible units thought to exist in the eligibility unknown group, which would simply be U*E/K. The CASRO method is:

$$\boldsymbol{RR} = \frac{\boldsymbol{R}}{\boldsymbol{E} + \boldsymbol{e_C} * \boldsymbol{U}}$$

where:
RR = response rate
R = respondents
E = eligible sample units
e_C = CASRO eligibility rate (eligible units divided by the sum of the eligible and ineligible units)
U = unknown sample units refers to the sample units with unknown eligibility.

For example, if a Random-Digit-Dialling survey was conducted and 20,000 telephone numbers are called, there may only be 4,800 households recruited successfully to participate in the survey, of which only 1,579 complete the survey. The rest of the sample is characterized by refusals (1,200), ineligible respondents (2,400) and 11,600 cases where eligibility is unknown. The eligibility rate for this survey is:

(4,800+1,200)/(4,800+1,200+2,400) = 71 percent.

Applying the CASRO formula for response rates, the result is 11.1 percent, a very low response rate for the entire survey procedure, because CASRO requires that 71 percent of the unknown eligibility cases are assumed actually to be eligible.

The AAPOR has devised a number of response rates, of which the one known as Response Rate 3 (RR3) is the preferred one, and the one we recommend in this paper. In the formula for RR3, the AAPOR leaves the eligibility rate to the discretion of the analyst, requiring only that documentation be provided as to how the eligibility rate was calculated. Indeed, one could suggest that the CASRO formula is actually a special case of the AAPOR formula, in which the method of estimating the eligibility rate is defined in this particular way. The formula for response rates (RR3) devised by the AAPOR, is shown below:

$$\boldsymbol{RR3} = \frac{\boldsymbol{R}}{\boldsymbol{E} + \boldsymbol{e_A} * (\boldsymbol{U})}$$

where:
R = respondents
E = eligible sample units
U = unknown eligibility units
e_A = estimated proportion of cases of unknown eligibility that are eligible.

The AAPOR formula (RR3) is only slightly different from the CASRO formula, and this difference is the use of e_A as opposed to e_C.

The real question, in relation to the calculation of response rates, is the determination of the eligibility rate for the unknown sample units (Ezzati-Rice *et al.,* 1999; Brick *et al.,* 2002; AAPOR, 2004). The AAPOR definition of response rates (RR3) states that the estimation of the eligibility rate is left to the discretion of the organisation(s) and individual(s) undertaking the research, that the estimate for eligibility from unknown cases should be based on the best available scientific information, and that the basis of the estimate must be explicitly stated and explained. A relatively recent study used the AAPOR (RR3) formula to calculate response rates (Keeter *et al.,* 2000). In this study the eligibility rate for the unknown sample units was estimated to be around 20 percent as a result of investigations that indicated that around 20 percent of eligible units were among the unknown sample units.

2.2 Estimating the eligibility rate

Sampling units that have unknown eligibility will result, in a telephone recruitment survey, from telephone numbers for which no determination is able to be made about whether or not there is an eligible sampling unit at that phone number. For face-to-face interviews, these sampling units will result from addresses that could not be found and from addresses where no answer is able to be obtained on the maximum number of attempts permitted in the survey. In a postal survey, the unknown eligibility units are all units to which a postal survey was sent, and from which nothing is heard. In postal surveys, however, there is also usually little possibility of determining ineligibility. Ineligible sampling units are very unlikely to return surveys, so that it is likely that these will remain in the unknown eligibility group.

We would suggest that the eligibility rate for unknown eligibility units would generally be lower than that for the eligibility known units. In a telephone survey, the eligibility unknown units are predominantly unanswered telephone numbers. It is likely that these will contain a larger proportion of ineligible numbers than is the case in the total population of telephone numbers. This is also likely to be true in a face-to-face interview survey, where addresses at which no response is able to be obtained are more likely to be vacant on a temporary or permanent basis than is the case among those units where eligibility is determined. Absent any other information, we would suggest that the eligibility rate should be about two-thirds for the unknown eligibility units than it is for the known eligibility units. Thus, if the eligibility rate is determined to be 60 percent for those units where eligibility is determined, the rate to be used for the unknown eligibility units would be 40 percent.

3 Transport Measures of Quality

In this section, we consider variables that have not been used elsewhere and are of specific application to transport surveys. The variables considered are specific to personal travel surveys and are those that are temporally and spatially stable and, therefore, should acquire similar values among surveys. Special circumstances may cause values to deviate from the norm but, generally, deviations from standard values are an indication of a breach in the quality of the data.

For the variables considered in this section, it is necessary to agree on which variables should feature as transport measures of data quality, what their expected values are, and what deviation from these values should be considered tolerable. It is common practice to compare values from new surveys with those from surveys that are considered reliable. Data sets that are generally considered to produce reliable results include the national census, national household surveys such as the US Nationwide Personal Transportation Survey (NPTS) and the US National Household Travel Survey (NHTS), or carefully designed and executed local household travel surveys. The Institute of Transportation Engineers published average values of socio-economic, travel, vehicle usage, time-of-day behaviour, and network characteristics from twelve urban areas in the US specifically for the purpose of providing such a reference for new surveys (ITE, 1995). Average values from numerous past surveys have also been published in *NCHRP Synthesis 236* (Stopher and Metcalf, 1996) and *NCHRP Report 365* (Martin and McGuckin, 1998).

It is intuitively expected that variables that relate to the characteristics of a traveller rather than the environment in which travel occurs, are more likely to be stable among surveys. For example, it is known that trip lengths are affected by metropolitan size, and mode choice is affected by the level of public transport service and road congestion existing in an area. On the other hand, the number of trips made by an individual are primarily determined by the characteristics of the individual. With this in mind, candidate variables investigated for stability in this study were those that characterise the traveller. Variables investigated included:

- The proportion of non-mobile households;
- The proportion of non-mobile persons;
- The average activity rate per household;
- The average activity rate per person;
- The average trip rate (overall) per household;
- The average trip rate (overall) per person; and
- The average trip rates per household and per person for specific trip purposes.

While activity rates were investigated in our research (NCHRP, 2006), these are most useful for activity surveys and are not discussed further in this paper. In the following sections, we discuss non-mobility and average trip rates as measures of quality in transport surveys.

3.1 Personal and household non-mobility

The number of households or persons making no trips during a travel survey are seldom reported in survey documentation. However, the statistic can easily be calculated from the raw data. Values of non-mobile rates from several past studies are shown in Table 1. The values in the table are the percentage of persons or households who reported no travel activity during an observation period of one day.

The use of non-mobility as a measure of data quality has been suggested in the past (Kitamura, 1995). The premise is that beyond the actual immobility of some respondents, failure to report trip-making reflects a shortcoming in the survey. The reason for respondents failing to report trips actually made are varied. Some do not want to go to the time and effort of reporting them. Others may believe that the travel they made was too insignificant to be of interest to those conducting the survey. Some merely forget the travel they did make or forget to record it. However, in all cases the incidence can be reduced by good survey design and execution.

Table 1: Percentage of Non-Mobiles Observed in Past Travel Surveys

Survey and Date	Percentage Non-Mobile	
	Persons	Households
Adelaide, 1977	13	-
Adelaide, 1999	13.4 [a]	8.5[b]
Dallas Fort Worth, 1996	-	0.8
NPTS, 1990	21	-
Ohio, Kentucky, Indiana Survey, 1990	17	1.6
Salt Lake City, 1993	18	0.9
San Francisco, 1981&1990	18	-
Southeast Florida Regional Characteristics Study, 2000	-	1.3
Sydney, 1981	22	-
Victoria, 1999	20	10

[a] Percentage of non-mobile persons on day 1 (day 2 was 15.4%) .
[b] Percentage of non-mobile households on day 1 (day 2 was 10.3%).

The portion of recorded immobility that is true inactivity is difficult to estimate because at least some immobility on any given day is elective. For example, older people in particular may often choose to stay home all day. However, statistics are not available on elective immobility as a whole. On the other hand, there are those that are permanently or temporarily incapacitated and unable to travel, and some statistics are available for these cases. In the US, approximately 12 percent of the population is characterised as 'severely disabled' and approximately one-third of these people require 'assistance with activities of daily living' (US Bureau of the Census, 1997). Individuals are classified as severely disabled if they use a wheelchair, cane, crutches, or a walker, if they have mental or emotional conditions that seriously interfere with everyday activities, if they receive federal benefits based on an inability to work, have Alzheimer's disease, mental retardation, or another developmental disability, or are unable to work or perform every-day activities such as walk, speak, hear, grasp objects, etc. Those needing assistance with 'activities of daily living' are individuals requiring assistance in moving inside or outside the home, getting in or out of bed, bathing, dressing, eating, taking medicine responsibly, using the telephone, preparing meals, etc. Thus, while some of the severely disabled persons may indeed travel on any given day, virtually none of those requiring assistance with activities of daily living are expected to travel. This is directly comparable to the Australian experience; in 2003, 20 percent of Australians reported a disability and 61 percent of those individuals (12.2 percent of total population) reported "needing assistance to manage their health conditions or to cope with the activities of everyday life" (Australian Bureau of Statistics, 2003, p6). Therefore, it appears that between four and ten percent of the population is either unable or unwilling to travel due to a disability.

Illness that prevents an individual from travelling is another possible reason why individuals may not travel on any given day. Statistics from the US Bureau of Labor Statistics and from Canadian Statistics suggest that, on average, the number of days lost per worker due to injury or illness is seven days per annum (Bureau of Labor Statistics, 2003, Statistics Canada, 2002). Similarly, the Australian National Audit Office suggests that an average of 6.8 days of unscheduled absences from work are taken per annum among private sector workers and 11.9 days are taken in the public sector (ANAO, undated). Thus, assuming 264 working days in the year, on any given day a worker would have approximately a three percent (7/264) chance of missing work due to injury or illness. What proportion of these workers would make no trips is not known, but the statistic does show that the source of immobility due to illness is small relative to that due to disability.

The statistics in Table 1 will, in all cases, include some fictitious immobility, resulting from people using this as a means to avoid completing the survey, without actually having to give a refusal. Past studies suggest that typical non-mobile rates are 20 percent at the person level and one percent at the household level. It is recommended that these values serve as reference values against which new surveys are measured. Person non-mobile rates less than 20 percent and household non-mobile rates of less than one percent, suggest data quality that is better than average although no clear interpretation of data quality *vis-à-vis* the non-mobile rate is available at this time. Similarly, person non-mobile rates in excess of 20 percent, and household non-mobile rates in excess of one percent, indicate below average data quality.

3.2 Trip rates

Reviewing past experience on the stability of trip rates among surveys suggests that there is indeed a degree of stability among the values. A review of more than 50 recent urban travel surveys (Stopher and Metcalf, 1996) shows that the number of trips per person per day can be expected to range between 3.5 and 4.5, and trips per household per day between 8 and 11 (Stopher and Metcalf, 1996). This is also supported by the research which led to publication of NCHRP 365 – the update of standard trip-making characteristics first established in NCHRP 187 in 1978 – that household trip rates vary between 8.5 and 9.2 trips per household per day (Martin and McGuckin, 1998). Household trip rates from a number of studies, including those from NCHRP 187 (Sosslau et. al, 1978), 236, and 365, are shown in Table 2. The data in Table 2 appear to support the contention that the average household trip rate falls within the range of 8-11 person trips per day.

As pointed out by Stopher and Metcalf (1996), measuring trip rates is not without ambiguity. First, there is seldom a clear specification of whether the trip reported is a linked or unlinked trip. A single linked trip between an origin and destination consists of two or more unlinked trips (or, synonymously, segmented trips) if the traveller changes mode, or if the trip is interrupted to drop off or pick up a passenger (Stopher and Metcalf, 1996; RTI, 1997). In transport planning, linked trips are typically used, and unlinked trips are combined to form linked trips before analysis begins. Reported trip rates are typically linked trip rates but care must be taken to ensure that this is the case since unlinked trip rates will inevitably be higher. Second, the definition of a trip has not been standardised and this can affect the observed rates. Specifically, the inclusion of all non-motorised travel and the inclusion of very short trips can alter the number of trips recorded. Third, the issue of weighting, employed to adjust the sample for bias, can affect trip rates. Weighting is conducted in a variety of ways during the processing of travel survey data, and the procedure used can affect the weighted trip rate. More importantly though, is knowing whether the reported trip rate is of weighted or unweighted trips. Weighted and unweighted trip rates can be quite different, as demonstrated in the NPTS 95 data where the weighted household trip rate is 10.5 compared to 9.7 for the unweighted trips. In most studies, if not specified, unweighted trip rates are reported. Fourth, care must be taken to ensure that the trips reported are person trips and not vehicle trips, since both are often reported in travel survey results.

Household trip rates by purpose are shown in Table 3. The values average 1.7, 4.7, and 2.8 person trips per day for home-based work, home-based other, and non home-based trip purposes, respectively. This implies an average all-purpose household trip rate of 9.2 person trips per day, which is consistent with the rates shown in Table 2.

Table 2: Average All-Purpose Household Trip Rate from Recent Travel Surveys

Survey	Survey Date	Person trips/hh/day
Home interview surveys	1956-1976	7.6-14.1
San Francisco	1981	8.71
Albany, NY (Capital District)	1983	8.25
Houston-Galveston	1984	9.32
12 urban travel surveys & NPTS 90	1985-1990	8.5-9.2
Denver, CO	1988	7.89
Philadelphia, PA – Southern N.J.	1989	7.81
51 urban travel surveys	1990-1995	8.91
Ohio, Kentucky, Indiana Survey	1990	10.03
Salt Lake City	1993	13.8
NPTS 95	1995	9.73
Oregon	1996	7.8
Dallas/Fort Worth	1996	9.47
Baton Rouge Personal Travel Survey	1997	9.69
Nashville, Memphis, Knoxville, TN	1998-2003	8.04 - 8.44
Adelaide	1999	8.30
Victoria	1999	8.77
South East Florida	2000	7.19
Florida	-	7.31 - 9.80
Twin Cities (urban)	2001	10.3
Twin Cities (rural)	2001	9.5
Atlanta (SMARTRAQ) (day 1)	2001-2002	8.06 – 8.54
Atlanta (SMARTRAQ) (day 2)	2001-2002	7.95

Table 3: Average Household Trip Rate by Purpose from Recent Travel Surveys

Survey	Survey date	Person trips/hh/day		
		HBW	HBO	NHB
San Francisco	1981	1.89	-	-
Houston-Galveston	1984	1.72	4.65	2.95
Philadelphia, PA – Southern N.J.	1989	2.14	4.03	1.64
Ohio, Kentucky, Indiana Survey	1990	1.72	-	-
Salt Lake City	1993	1.66	4.93	-
NPTS 95	1995	1.56	4.99	3.03
Dallas/Fort Worth	1996	1.63	4.68	3.16
Baton Rouge Personal Travel Survey	1997	1.57	4.94	3.18
Adelaide	1999	1.14	5.30	1.86
Victoria	1999	1.13	4.89	2.75

A problem with measuring trip rates at the household level is the impact household size has on the results. The effect of household size can be eliminated by observing trip rates per person. However, this will not necessarily reduce the variation in trip rate values because of the different levels of aggregation at which the two trip rates are measured. The Coefficient of Variation (COV) of the trip rates per person in Table 4 is 0.20 while the COV for the household trip rates shown as single values in Table 2 is 0.17. The average all purpose trip rate in Table 4 is 3.38 trips per person per day.

Table 4: Average All-Purpose Person Trip Rate from Recent Travel Surveys

Survey	Survey Date	Person trips/person/day
San Francisco	1981	3.40
Albany, NY (Capital District)	1983	2.05
Houston-Galveston	1984	3.48
Denver, CO	1988	2.54
51urban travel surveys	1990-1995	3.50
Ohio, Kentucky, Indiana Survey	1990	3.87
Salt Lake City	1993	4.23
NPTS 95	1995	3.76
Baton Rouge Personal Travel Survey	1997	3.70
Adelaide (day 1)	1999	3.54
Adelaide (day 2)	1999	3.34
Victoria	1999	3.34
South East Florida	2000	2.30
Atlanta (SMARTRAQ) (day 1)	2001-2002	3.90
Atlanta (SMARTRAQ) (day 2)	2001-2002	3.80

A review of the trip rates per person by purpose revealed considerable variation among the data sets considered in this study. Consequently, we were unable to identify representative values that could function as useful reference values.

It is recommended that the trip rates in Table 5, which include household trip rates, serve as reference values for future travel surveys. Deviations from these values must be interpreted by the analyst, because the specific relationship between trip rates and data quality has not been established. Note that the trip rates shown in Table 5 are linked, unweighted, person trips per day.

Table 5: Recommended Reference Trip Rates for Travel Surveys

Trip rate	Purpose	Mean Value	Range
Household	All	9.2	8 – 11
	HBW	1.7	-
	HBO	4.7	-
	NHB	2.8	-
Person	All	3.4	-

4 A case study

Having made these recommendations on possible measures of quality, it would be useful to see how they might apply in practice. Recently, ITLS conducted a travel diary survey in New South Wales (Stopher et al., 2006). This survey involved a panel of households completing two-day travel diaries at two points in time about nine months apart. The survey was administered as a telephone recruitment, followed by posting the diaries and other household and vehicle forms to each recruited household. Diaries were returned by post, using a stamped addressed envelope that was provided to each recruited household.

Each of the three measures of survey quality is estimated for the two waves of the panel. The surveys were conducted in four suburbs of Sydney: Ermington, Dundas, Woy Woy, and Ettalong Beach. The panel was designed as a subsample panel, in which more than sufficient households were recruited for the first wave, and the second wave was conducted with only those households that were still willing to participate, that had not moved out of the area, and that could be contacted.

4.1 Survey Response

Table 6 shows the total number of households contacted in each of the four suburbs surveyed. It also provides the actual numbers of households that were recruited and the number of those households that returned data in each of the before and after surveys. As a benchmark, postal surveys usually record response rates in the region of 20 to 25 percent for a one-off survey, based on known and estimated[1] eligible households. In this survey, we succeeded in obtaining a complete response (meaning that household and vehicle forms and diaries were filled out and returned) from 31.5% of known eligible households and 28 percent of the estimated and known eligible households (see Table 7). Given that households were recruited to a two-wave panel, this response rate is considered to be significantly higher than would usually be expected for such a survey.

Table 6: Responding Households for the Before and After Surveys[2]

Suburb	House-holds Contacted [3]	Eligible Households Contacted (Percentage of Total Households)	Households Recruited (Percentage of Eligible Households)	Households Returned Information in "Before" Survey (Percentage of Eligible Households)	Households Recruited for "After" Survey (Percentage of "Before")	Households Returned Information in "After" Survey (Percentage of "Before")
Ermington	1,973	1,314 (66.6%)	670 (51.0%)	406 (30.9%)	310 (76.4%)	277 (68.2%)
Dundas	1,507	985 (65.4%)	523 (53.1%)	328 (33.3%)	262 (79.9%)	219 (66.8%)
Woy Woy	993	727 (73.2%)	360 (49.5%)	232 (31.9%)	189 (81.5%)	181 (78.0%)
Ettalong Beach	709	487 (68.7%)	245 (50.3%)	141 (29.0%)	110 (78.0%)	97 (68.8%)
Total	5,182	3,513 (67.8%)	1,798 (51.2%)	1,107 (31.5%)	871 (78.7%)	774 (69.9%)

Table 7 shows that even though the attrition rate at 30 percent was slightly higher than predicted, the higher than expected response rate in the before survey meant that the number of households returning diaries still exceeded the number of target returns in all suburbs surveyed.

[1] Estimated eligible households are determined here by applying the CASRO formula described in Section 2.1. That is, by calculating the proportion of eligible households from the telephone numbers of known eligibility, and applying this rate to the telephone numbers for which eligibility was never established.

[2] Note that while this table shows *responding* households, different combinations of these are used in other tables, depending on their relevance (e.g. weekday, weekend, receiving tools, etc).

[3] Includes no contact after 5 attempts (449), ineligible households (128), invalid numbers (809), and households not in the sample area (65) for a total of 1,451 non-contactable and ineligible households. In addition, there are 147 households with a language barrier (therefore ineligible) and 71 for which there were still outstanding call backs.

Table 7: Response and Attrition Rate

Response Disposition	Percentage of Contacted Households	Percentage of Known Eligible Households	Percentage of Potentially Eligible Households
Response Rate (Before)	62%	32%	28%
Response Rate (After)	89%	22%	20%
Attrition Rate		30%	

Once all data entry was completed and determination made of usable responses, the number of responses that were usable in the before survey declined from 1,107 to 1,051. The loss of 56 households, due to incomplete data, is also considered to be very small. This means that the final useable response represents a response rate of 26.6 percent of the known and estimated eligible sample, which is high for a postal survey.

Because this survey was structured as a panel survey, the second-wave response is also a useful measure of data quality. We were able to contact and recruit 78.7 percent of the households that completed surveys in the first wave. Households that had moved out of the area, were no longer contactable with the information provided in the first wave, or had since decided not to continue in the survey totalled 21.3 percent of the before households. Of the households recruited for the second wave, 89 percent completed the survey task, thereby providing us with a final response from the second wave of just under 70 percent of the wave 1 households. In the second wave, we also lost households that returned survey materials that were subsequently found to be too incomplete to be used. This reduced the final sample from 774 households to 726, for a loss of 48 households. Thus, the final response rate from the second wave was 18.8 percent of known and estimated eligible households from the initial contacts. While these response rates may be considered rather low in absolute terms, for a postal survey with telephone recruitment for a two-wave panel, these are considered to be well above average response rates.

4.2 Non-mobile households

A second measure of quality is the rate of non-mobile persons and households in the data. Rates of non-mobility for weekends are not widely reported (because weekend data are rarely collected in standard household travel surveys), but may be expected to be higher than on weekdays. One of the problems, however, with non-mobility is that it may be used by respondents as a benign form of non-response. In other words, in a diary survey, where respondents report the places they visit, some respondents will always realise that by claiming not to have travelled anywhere on a diary day, the task of completing diaries will be greatly reduced. To date, no one has been able to establish the true rate of immobility in the population, as opposed to the mix of real and fictitious immobility.

In this survey, which used a two-day diary, it is notable that the second diary day exhibits a significantly higher rate of non-mobility than does the first day as shown in Table 8. The survey results suggest that the higher rates of non-mobility for Day 2 may well be a measure of respondent fatigue, which is a part of respondent burden. The percentages in Table 8 are the percent of all respondents on that day that reported no travel. It should be noted that there was a technical problem in wave 1 that meant that we used the actual non-mobility rates from wave 2 for wave 1 for the first day, with the balance of the non-mobility assigned to day 2.

Looking at Day 1, both waves show a very similar pattern, with the highest non-mobility day on the first of the two diary days being Saturday, and Sunday being the second highest and Thursday the third. Looking at the second day, this analysis suggests that perhaps as many as 400 persons in the first wave used fictitious non-mobility as a non-response mechanism.

This is a slightly lower rate of potentially fictitious non-mobility than was found in the second wave (which has a smaller sample size), where about 350 person days appear to be potentially fictitious.

Similar results were obtained for household non-mobility. As expected, the numbers of non-mobile households were much lower than non-mobile persons because, for a household to be non-mobile, none of its members could travel on the diary day in question. Our analysis suggested that about 165 households may have reported no travel on the second day as a nonresponse mechanism in the first wave, while as many as 130 households used non-mobility on Day 2 as a nonresponse device in the second wave. The level of immobility of 2.5 percent for Day 1 in both waves was slightly higher than the 1 to 2 percent usually expected, but is within reason, given the sample size and the inclusion of weekends. In fact, for weekdays only, the level is 1.8 percent, which is within the expected range. The Day 2 rate is 10 times the expected level, and therefore indicates nonresponse. It is of interest to note that fifteen of the sixteen households that reported no travel on either day were one-person households, and the other household was a 2-person household. Also, these non-mobile households occurred most often on Thursday-Friday and Saturday-Sunday, each of which has 4 non-mobile households.

Table 8: Person Non-Mobility Counts and Rates for the Panel

Diary Day		Day of Week							Total
Wave	Day	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	
1	1	9 (6.1%)	15 (3.9%)	21 (5.1%)	38 (7.3%)	20 (4.4%)	45 (12.0%)	18 (8.5%)	164 (6.6%)
1	2	48 (23.5%)	20 (14.7%)	61 (16.2%)	83 (20.0%)	108 (20.9%)	107 (23.5%)	108 (28.7%)	537 (21.6%)
1	1 & 2	0	4	7	8	4	10	2	35
2	1	7 (6.1%)	11 (3.9%)	14 (5.1%)	26 (7.3%)	15 (4.4%)	31 (12.0%)	14 (8.5%)	118 (6.6%)
2	2	40 (24.4%)	26 (22.8%)	62 (21.9%)	67 (21.7%)	77 (24.5%)	101 (29.6%)	98 (38.0%)	471 (26.3%)
2	1 & 2	5	9	9	18	9	24	7	81

Overall, the rate of non-mobility found in this survey, while being a little higher than would normally be expected, is nevertheless at a reasonable level and does not indicate excessive use on Day 1 of non-mobility as a nonresponse mechanism. However, on Day 2, it is apparent that much non-mobility reporting is likely to be fictitious. However, the two waves of the survey have comparable levels of such fictitious reporting. In addition, the rates of non-mobility for Day 1 are within acceptable limits, suggesting that non-mobility as a non response mechanism was used principally for the second day of the diary.

4.3 Trip Rates

The third measure of data quality is the trip rates. Average per person linked trip rates should normally fall in the range of 3.5 to 4.5, although values of up to 5 are acceptable. Household linked trip rates should average in the region of 8 to 11 trips per day, depending on average household size. Where household size is substantially below the normal average of 2.4 to 2.6, a lower average household daily trip rate should be expected. These average trip rates are based on weekday travel. There are no good benchmark rates for weekend travel. In this survey, the trips reported are linked trips: the diary asked for main mode of travel and did not ask for people to report individual trip segments, although a few used the diary to report trip segments.

Table 9 shows that the actual household trip rates on weekdays in all suburbs, except Ettalong Beach, were in the expected range, with even the Day 2 rates being close to the expected averages, despite the second day drop off in reporting. In Ettalong Beach the figures are considerably lower, which we believe is a result of the small average household size and the number of retired persons in that area.

Similar results were found for person trip rates, with values on weekdays of 3.5 to 4.5, and all areas except Ettalong Beach showing such rates. Ettalong Beach is lower, but this is accounted for by the nature of the sampled population in that suburb, which is significantly older and includes a much larger proportion of retired persons. Such a population would be expected to be less mobile and therefore show a lower person trip rate. Although there is little information available to compare against, the generally lower trip rates of 2.8 to 3.5 on the weekend are also intuitively expected. Based on Table 9, and the analysis of person trip rates, it appears that the survey has recorded trip rates that are well within acceptable bounds both at the person and household level.

Table 9: Household Trip Rates on Day 1 and Day 2 – Weekdays

Suburb	Before				After			
	Day 1		Day 2		Day 1		Day 2	
	Sample	Trip Rate	Sample	Trip Rate	Sample	Trip Rate	Sample	Trip Rate
Ermington	293	10.77	261	9.05	198	10.67	176	8.79
Dundas	243	10.16	211	8.61	160	10.06	146	8.3
Woy Woy	309	10.32	264	8.75	220	10.10	193	8.09
Ettalong Beach	109	6.06	97	4.74	74	6.85	65	4.52

5 Conclusions

This paper has described three measures of survey data quality with application to person and household travel surveys – the response rate calculated according to the AAPOR formula three method, the non-mobility rate at the person and household level, and weekday trip rates – which provide a more complete picture of the quality of a data set than just the response rate. In applying these measures to a recent two-day, two-wave panel survey, the measures were found to be useful in measuring the quality of the data, and provided a basis for assuming that the data would be of use in analysis. Perhaps of more use still, the non-mobility analysis was able to identify a potential problem with the second day's data from the diaries, where people apparently used the false reporting of no travel as a mechanism to avoid filling out more of the diary. If the data were to be used from this survey in absolute form, it would probably be necessary to disregard the second day of data, or to apply substantial factors to it to correct for the lack of reporting on the second day. The non-mobility analysis also points to a problem with multi-day diaries, where people become tired of completing them and look for a means to avoid the continuation of the reporting task. This was also reflected in a drop in trip rates for the second day, as would be expected.

In fact, the main use for these data was to undertake a comparison between the two waves. In this case, the analysis showed that each of the two waves was similarly affected, and would therefore lead to a decision that both days of data could be used for such a comparative analysis.

These conclusions about the usefulness of the data could not have been drawn by considering only the response rate.

6 Acknowledgement

The authors gratefully acknowledge permission from the New South Wales Department of Planning to use the data collected for a project sponsored by them. The opinions and conclusions expressed in this paper are those of the authors and do not represent a position of the Department. The authors are solely responsible for any errors in this paper.

7 References

AAPOR (2004). "*Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*", 3rd Edition. Lenexa, Kansas: American Association for Public Opinion Research, accessed on 12/03/04; www.aapor.org/pdfs/standarddefs2004.pdf

Australian Market and Social Research Society (2000) "Call for action on response rates", *Research News November 2000.* Accessed on 06/07/2006; http://www.mrsa.com.au/index.cfm?a=detail&id=152&eid=33

ANAO (undated) *Absence Management in the Australian Public Service*, The Auditor-General, Audit Report No.52 2002–03 Performance Audit. Accessed on 5/7/2006; http://www.anao.gov.au/website.nsf/publications/bd2feab022f0a678ca256d4b000f5dfd

Australian Bureau of Statistics (2003) *Disability, Aging and Carers: Summary of Findings,* Catalogue Number 4430.30, accessed on 05/07/2006; http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4430.02003?OpenDocument

Beerten, R., Lynn, P., Laiho, J., and Martin, J. (2000) "*Response Rates as a Measure of Survey Quality*", Paper presented at the Fifth International Conference on Logic and Methodology, Cologne.

Brick, J. M., Montaquila, J. and Scheuren, F. (2002). "Estimating Residency Rates for Undetermined Telephone Numbers", *Public Opinion Quarterly*, Vol. 66, pp 18-39.

Bureau of Labor Statistics (2003). "Occupational Injuries and Illnesses: Industry Data (1989-2001)", U.S. Department of Labor. http://data.bls.gov/cgi-bin/dsrv (accessed 12/16/03).

CASRO (1982). "*On the Definition of Response Rates: A Special Report of the CASRO Task Force on Completion Rates*", Council of American Survey Research Organizations www.casro.org Date of ref. 6/11/02

CMOR (1999). "Survey Response Definitions", Council of Marketing Opinion Research www.cmor.org/downloads/resp_tools/cmor.pdf Date of ref. 8/11/02.

De Heer, W.F. and Moritz, G. (1997). "*Data Quality Problems in Travel Surveys, An International Overview*", Workshop on Respondent Issues: Sampling, Weighting, and Non-Response, Transportation Research Board Transportation Research Circular E-C008: Transport Surveys: Raising the Standard.

Dillman, D.A.. and Carley-Baxter, L.R. (2000). "Structural Determinants of Mail Survey Response Rates Over a 12 Year Period, 1988-1999", http://survey.sesrc.wsu.edu/dillman/papers.htm Date of ref. 5/11/02

Dillman, D.A.., Phelps, G., Tortora, R., Swift, K., Koherll, J., and Berck, J. (2001). "Response Rate and Measurement Differences in Mixed Mode Surveys: Using Mail, Telephone, Interactive Voice Response and the Internet", Draft Paper, http://survey.sesrc.wsu.edu/dillman/papers.htm Date of ref. 5/11/02.

Ezzati-Rice, T.M., Coronado, V.G., Frankel, M.R., Hoaglin, DC., Loft, J.D., and Wright, R.A. (1999). "Estimating Response Rates in Random-Digit-Dialing Surveys That Screen For Eligible Subpopulations", www.jpsm.umd.edu/icsn/papers/EzzatiRiceCoronado.htm. Date of ref. 7/11/02.

ITE (1995). *Urban Travel Characteristics Database*, Informational Report prepared by Technical Council Committee 6Y-46, (Chmn.) Richard S. Marshment, Publication No. IR-078, Second Printing, Institute of Transportation Engineers, Washington, DC, 206 pages.

Kalfs, N. and H. van Evert (2003). "Nonresponse in Travel Surveys", in Stopher, P.R. and P.M. Jones, *Transport Survey Quality and Innovation,* Elsevier Press, pp. 567-586.

Kam, H.B. and Morris, J. (1999). "Response Patterns in Travel Surveys: The VATS Experience", www.trc.rmit.edu.au/Publications/Papers/responsepatterns.pdf, Date of reference 10/02/03

Keeter, S., Miller, A., Kohut, A., Groves, R.M., and Presser, S. (2000). "Consequences of Reducing Non-response in a National Telephone Survey", *Public Opinion Quarterly*, Volume 64, pp 125-148.

Kitamura, R. (1995). "Time-of-Day Characteristics of Travel: An Analysis of 1990 NPTS Data", Special Reports on Trip and Vehicle Attributes, Federal Highway Administration, U.S. Department of Transportation, Washington, DC.

Lynn, P., Beerten, R., Roeland, L., Jean, J., and Jean, M. (2001). *Recommended Standard Final Outcome Categories and Standard Definitions of Response Rates for Social Surveys*, Working Papers of the Institute for Social and Economic Research, paper 2001-23. Colchester: University of Essex, http://iser.essex.ac.uk/pubs/workpaps/pdf/2001-23.pdf , accessed on 5/03/04

Martin, William A., and Nancy A. McGuckin (1998). "Travel Estimation Techniques for Urban Planning", *National Cooperative Highway Research Program (NCHRP) Report 365*, Transportation Research Board, Washington DC.

NCHRP (2006) *Standardization of Personal Travel Surveys* Final Report on Project 8-37, National Cooperative Highway Research Program, Transportation Research Board, Washington, DC.

Richardson, A.J. (2000). "Behavioural Mechanisms of Non-Response in Mailback Travel Surveys," paper presented to the Transportation Research Board, 79th Annual Meeting, January 9-13; Washington, DC.

Richardson, A.J. and Meyburg, A.H. (2003). "Definitions of Unit Non-Response in Travel Surveys" in Stopher, P.R. and P.M. Jones, (eds.) *Transport Survey Quality and Innovation*, Elsevier Press, pp. 587-604.

RTI (1997). *The User's Guide for the Public Use Data Files: 1995 Nationwide Personal Transportation Survey,* Research Triangle Institute, Publication number FHWA-PL-98-002, HPM-40/10-97(2M), Federal Highway Administration, U.S. Department of Transportation.

Singer, E., Van Hoewyk, J., and Maher, M.P. (2000). "Experiments with Incentives in Telephone Surveys", *Public Opinion Quarterly*, Vol.64, No. 2, pp171-188.

Sosslau, A. B., A. B. Hassam, M. M. Carter, and G. V. Wickstrom (1978). "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters – User's Guide", National Cooperative Highway Research Program (NCHRP) Report 187, Transportation Research Board, Washington DC.

Statistics Canada (2002). "Days Lost Per Worker Due to Illness of Disability, by Sex, Canada and Provinces", http://www.statcan.ca/english/Pgdv/health47a.htm (accessed 12/16/03).

Stopher, P.R. and Metcalf, H.M., (1996). *Methods for Household Travel Surveys*, NCHRP Synthesis of Highway Practice 236, Transportation Research Board, Washington, DC.

Stopher, P.R., N. Swann and T. Bertoia (2006). "Evaluation of a Pilot TravelSmart Program for New South Wales", paper submitted for presentation to the 29th Australasian Transport Research Forum, Gold Coast, September.

US Bureau of the Census (1997). "Americans with Disabilities: 1997 – Table A", http://www.census.gov/hhes/www/disable/sipp/disab97/ds97ta.html (accessed 12/16/03).