

International Steering Committee for Transport Survey Conferences

Workshop Synthesis: Dealing with immobility and survey non-response

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Abstract

This paper discusses the related issues associated with dealing with immobility and survey non-response within survey design, sampling protocols and for different survey instruments and methodological approaches. How to develop new tools and methods to capture the travel under-surveyed, ‘hard to reach’ and ‘survey shy’ populations was discussed. Also, how to adapt standard survey designs and sampling approaches to include overlooked population sectors, such as young people, non-travellers and the residents of informal settlements in developing countries. The paper recommends that best known practice in this area is a long way from common practices, and that the academic, commercial consultancy and policy worlds are very different places. This raises the need to develop some minimum standards/checklists of survey inclusion protocols, together with basic training on sample composition, screening and proxy data recording.

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1. Introduction

This workshop focused on two different, but often related, issues of immobility and non-response in travel surveys. The workshop topic is linked to two previous workshops from the International Conference on Transport Survey Methods series: i) *Survey methods for hard-to-reach groups and modes* (Ampt and Hickman, 2014) and

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ii) *Sampling issues, data quality & data protection* (Armoogum and Dill, 2014).

Different features of survey design (both qualitative and quantitative) were discussed in the workshop, for instance how to improve survey design in order to capture under-represented population groups, such as young people and other survey-shy populations. We also considered how to adapt our standard travel survey methods for use in development contexts, in informal settlements, with slum dwellers, who are regularly overlooked across all survey sectors.

The session combined short presentations to provoke groups discussions, which were largely targeted towards how to better understand why certain population groups systematically fail to respond to, or are overlooked by traditional travel surveys, how this affects the datasets that we have, and how in turn this might influence the outcomes of our mathematical models, and ultimately our policy decisions. We also used some gaming techniques such as Edward de Bono's *Six Thinking Hats* to liven up our powers of creativity and produce some 'blue-sky' ideas.

The introductory session, discussed the scope of the population for which daily mobility activities are to be evaluated, i.e. everybody in the population or only the people who travel? We also explored why it might be important for researchers and policymakers to understand more about the issue of immobility, and its links with (or not) the various problems of survey non-response.

The second session was specifically dedicated to the topic of recorded immobility, and the third to the topic of survey non-response, and specifically the difference between non-travel and soft refusal. Sections 2 to 4 of this report summarize the main discussions from each of these three sessions.

The conclusion (section 5) is mainly a synthesis of different ways to deal with soft refusal. Recommendations (section 6) are presented in terms of future research as well as in terms of policy, and references (section 7) are given for the issues which could not be developed during the workshop.

2. What to measure? From whom?

The main questions that we explored in this first session were as follows:

- Who should we survey and why?
- What should we measure and from whom?
- What/who are the surveys used for?
- What are the barriers to survey participation: instrument design, sampling frames, cost or other?
- Is wide survey inclusion necessary or can we do other things to understand the behaviours of non-respondents?

We took as our starting point the current Eurostat guidelines on Passenger Mobility Statistics:

<https://circabc.europa.eu/.../Eurostat%20Passenger%20Mobility%20>, which states:

“The ideal situation would be to have information on mobility of all persons within a country (or zone), irrespective of their nationality and permanent residence. However, sampling frames used tend only to include country inhabitants (nationals and non-nationals within a local residence) and not for instance tourists, cross-border commuters from neighbouring countries, exchange students, etc.”

“The term 'reference population' refers to the population group for which the collected information is meant to be representative and it usually means the entire country population. The country population includes all inhabitants of the territory irrespective of kind of residence and including any non-nationals with a residence in the country. This means that both residents living in families and residents in institutions for e.g. elderly or disabled as well as students for a short course or employees at short positions are included.”

“The reference population... should include all country residents aged 15 to 84 inclusive.”

It has been regularly noted within both national and local travel surveys that some population groups are systematically under surveyed; most notably, young people, ethnic minorities, low- and high-income, slum dwellers, people living in institutions, etc. Within institutions, young workers and students are quite mobile, while elderly and disabled, as well as prisoners and members of religious communities, have recorded low mobility.

The question we first asked is, do these under-surveyed populations really matter for transport research, if they do not travel? The simple answer to this complex issue was that, yes, we do need to understand the travel behaviours of

these ‘hard to reach’ groups, especially if they behave differently from the average population. Failure to capture these differences can lead to significant biases within transport models, which can in turn lead to bad decision-making in terms of the provision of infrastructure or new transport services. This can mean that some populations remain under-served and effectively excluded from the transport system, with some serious social repercussions. It was also noted that sometimes understanding the role of immobility can be as important as people’s actual mobility. For example, when designing sustainable mobility policies to ensure that transport systems can continue to support quality of life in the context of travel demand reduction.

Some segments of the population are hard to reach, and this is even more the case in developing cities, where large sectors of the population are living in informal settlements. These populations and communities are often considered to be outside of the remit of public sector service providers, and so do not get surveyed for this reason. In other instances, they are overlooked or under-sampled because survey companies find them difficult to recruit at the household level.

In the first presentation, Bruna Pizzol discussed her study of slum dwellers in Sao Paulo, who she identified as not even being enumerated within the Brazilian Census. The study demonstrated how a description of people’s local and external mobility could be obtained through a smartphone application, which proved quite consistent with data gathered through a conventional PAPI travel diary. To address non-response issues in her survey, the data collection process relied on an intense consultation plan with the community, by involving local non-profit organizations in the design and by providing constant updates to the community stakeholders. This intense communication also allowed for minimizing the risks of exposing interviewers to local organized crime. (Pizzol et al., 2017). However, concerns were raised within the workshop about the ultimate suitability of using mobile phone applications in this context, as it could be bringing new biases into the sample. For example, older people may not have access to the new mobile technology or be comfortable with their use (15% of total households contacted in the slum).

In the second presentation, Mark Bradley discussed a new analytical approach to explain the peak car travel for young adults (Bradley et al., 2017). There is widespread evidence that young adults have the highest non-response bias (under-reporting of trips) for diary-based surveys, but it is not clear if this bias has been growing over time. There may be some evidence to suggest that the often-reported reductions in travel by this cohort could be a function of under-sampling in National Travel Surveys rather than an actual change in young people’s travel behaviour. Traditionally, proxy reporting by parents has been used to capture the travel of young people within the household who have not completed a diary. This could lead to severe under-reporting of trips, as parents are often not privy to the minutiae of their teenagers’ daily activities.

3. Immobility

Immobility is not exceptional within travel surveys. If it is defined as staying home without entering a public space during a whole week day, it is commonly admitted that 8 to 12% of the population will be captured as immobile at some point (Madre et al., 2007), even if this global figure varies substantially across age groups, zones of residence, days of the week, etc.

It was noted that a particular case of unit non-response is soft refusal (i.e. people declaring that they have stayed at home in order to escape from a long description of their trips). This causes an over-estimation of immobility, leading to major biases in the estimation of totals for the whole population (e.g. number of trips, car traffic, GHG emissions, etc.). The COST action SHANTI (Armoogum et al., 2014) has succeeded to harmonize National Travel Survey results for the number of trips per day per mobile person, but not for the proportion of mobile persons.

Immobility depends not only on the characteristics of individuals, but also where they live and what the main features of their neighbourhoods are (see the example of Rio de Janeiro in (Motte-Baumvol et al., 2016), as well as of Montreal where Moulin (2018) has shown that “immobility among the elderly is correlated with ageing, the lack of access to a car, no being employed, and living in a low-income area and far from public transport”).

Considering immobility over one week, 51% of adults have stayed at home during at least one of the 7 last days (31% over the 5 last working days), while only 3% (residents in institutions excluded) did not get out during the week before the survey, according to the 2007-08 National Travel survey conducted in France (Motte-Baumvol and Bonnin, 2017). Thus, a longitudinal perspective is very helpful to identify true immobility from soft refusal.

The presentation by Mathijs de Haas in this session was based on the Netherlands Mobility Panel (de Haas et al.,

2017a). The authors noted: on the one hand, the truly immobile people are an interesting and important group to study, not only from a research point of view, but also in light of policy making (e.g. in favour of social inclusion and participation, for monitoring equity and diversity, issues of justice and fairness). On the other hand, soft-refusal has a negative impact on data quality.

Three methods were proposed in the paper to identify possible soft refusers and tested on the Netherlands Mobility Panel. These methods are: respondent attrition (i.e. i) last participation before abandoning the panel, ii) modelling the probability of out-of-home activity, and iii) questionnaire response behaviour measured as straight-lining of grid questions). By combining the three methods, 5% to 10% of respondents were found to be at high risk of exhibiting soft refusal, and their data should therefore be treated with extra caution.

A second important point that was raised by the study, is that immobility is not only about low mobility. When only a few days of the week are ‘immobile days’, it can be due to the household’s or individual’s purposeful management of the program of activities over a longer period of time (e.g. over one week, or better 9 days (from Saturday to Sunday next week) in order to capture the variability between weekend days). Considering the intensity and diversity of trips during mobile days, different compensatory effects can appear according to trip purpose: e.g. more trips for food shopping and personal business (health) on mobile working days. Moreover, immobility is important for people with a low mobility for leisure.

In a recent paper, Ferreira et al. (2017) proposed that such immobility may become a form of ‘collective resilience’ in the context of the policy drive towards low carbon mobility options, by means of promoting localism, virtual travel, slowness and stillness. The authors identified a problematic knowledge gap within models of travel behaviour which are based on high-speed, long distance and high-frequency mobility. They suggest that a greater focus on immobility, why, where and when it occurs, and for who, is needed to ensure inclusive mobility futures.

4. Non-response

The workshop established the various types of ‘missing data’: some derived from limitation in the scope of the survey protocol (section 2), to the more usual cases of either a) total non-response (i.e. no information about the unit selected other than sample frame) or, b) partial non-response (item non-response and missing variables, when a unit selected responded only to a part of the survey and not all interesting variables (e.g. no question about income). This workshop was tasked with the issue of total non-response, referring specifically to the issue of item non-response).

Simple procedures exist to improve survey response overall during pre-notification period, and through follow-up with respondents who do not complete the survey (see Armoogum et al., 2014 for more on this). However, use of incentives can sometimes bias the overall response (e.g. complete household records in the British NTS are suspected to generate soft refusals/immobile records).

After the main data collection, the next question is what to do with non-response? Is it useful to make a second attempt for surveying non-respondents through a different mode of data collection? This could consist of few questions (e.g. on immobile days) asked by phone after a web survey, as planned for the next NTS in Sweden. An alternative solution is contacting non-respondents via the web and inviting them to a face-to-face or CATI survey; a good example is provided by the large-scale experiments conducted in Lyon (Bayart and Bonnel, 2008).

However, it was noted that the response rate for web-based surveys by non-respondents is actually very low (around 8%), and the sample may not be representative. For example, Internet users are usually highly active, have high-income and education levels, whereas non-respondents are usually less active, have low-income and education levels. Furthermore, even correcting for these structural factors, non-respondents to conventional surveys contacted by internet describe less trips (less walk and shopping), with more immobile days (Table 1). The selection bias can be estimated, as well as behavioural coefficients whatever survey mode. Future research should elaborate a methodology for the estimation of correction coefficients for each survey mode allowing to merge them, aiming to a better representation of the whole population.

The two presentations in the workshop about non-response focused on the use of longitudinal panel datasets. The interest in panel surveys is motivated by reduced costs (mainly for recruiting) by surveying less households, and the potential to develop sophisticated models that capture the day-to-day dynamics of travel behaviours over time. When multiple observations are taken from the same household, they are likely to be correlated across days. Therefore, they contain less new information than an independent observation taken from a new household. The correlation is likely to vary with the type of travel behaviour. For example, most people go to work in the same place every day, and are

likely to take the same mode to work, but their non-work activities may vary to a greater degree. Therefore, the key to understanding the value of multi-day survey data is to measure the relative amount of intra-person day-to-day variability versus the inter-person variability.

The highest correlation is for car ownership, while the lowest is for the total number of tours by person-type and tour purpose (Erhardt and Rizzo, 2017). It was not possible to conclude whether the willingness to participate (in a cross-sectional or panel survey) in a mode choice model leads to substantial improvements in the non-response (de Haas et al., 2017b).

5. Conclusion

Dealing separately with immobility and non-response in surveys on daily mobility is too much to be discussed over the six-hour period of our workshop sessions. However, focusing on immobility and soft refusal, even if multi-day surveys are burdensome, a longitudinal perspective seems most useful both to understand ‘non-exceptional’ patterns of immobility, and mobility patterns with compensatory effects over, e.g. one week. It also serves to detect individuals for whom the description of their trips is too burdensome, and thus prefer to declare that they have stayed at home, even when they have travelled i.e. ‘soft refusers’.

The bigger question is not how to detect survey non-response but what to do with it in our models once we have identified it? Most of these issues were far too technical to be discussed in any detail within a short session, but some general considerations can be found in (Richardson and Ampt, 2012) or (Armoogum and Madre, 2003). The main issue discussed in our workshop was whether it was better to duplicate already described trips by weighing (but this could be misleading if the travel characteristics of the missing sample are unknown or non-standard), or to add trips to people who did not describe any through imputations from other studies (Madre and Armoogum, 1998). A further question is what to do in the case of confounded (or non-ignorable) non-response, i.e. when the probability of responding depends on the response itself (Beaumont, 2000)? For instance, are people who refuse to wear a GPS less mobile than those who accept it?

The consequences in terms of variability and accuracy (calculation of confidence intervals) have to be investigated. Treating imputed values as observed values may lead to underestimating variance, thus over-estimating accuracy (Deville and Sarndall, 1994; Haziza and Picard, 2012). Considering weighing, “a covariate for a weighting adjustment must have two characteristics to reduce nonresponse bias, it needs to be related to the probability of response, and it needs to be related to the survey outcome. If the latter is true, then weighing can reduce, not increase, sampling variance” (Little and Vartivarian, 2005).

Immobility can be obtained through a retrospective question (over 7 days in the 2007–08 and 2018 French NTS), a multi-day travel diary (over one week in the British NTS), or even a panel survey (de Haas et al., 2017a) for the Netherlands and the on-going research by KIT and IFSTTAR on the German Mobility Panel. For detecting soft refusal, the question “why did you stay at home yesterday?” is not very informative, because most people answer that they did not need to move.

For example, in the French 1993–94 NTS, considering as ‘soft refusers’ those who gave this answer for the last Saturday and Sunday, as well as for the day before, would have reduced the rate of immobile persons on a weekday from 15% to 12%. In the 2007–08 French NTS, people were asked if they stayed at home (or in their garden) for each of the 7 days before the visit of the surveyor. The 15% of individuals who declared that they stayed at home the day before his/her visit (from Monday to Friday) were asked to describe the most recent weekday when they had made trips.

Of the total, 11% made weekday trips, while 3% stayed at home all 7 days and 1% moved only on Saturday or Sunday. The 11% who described their mobility for a day earlier than initially allocated made 21% less trips (maybe due to memory effect) but the distance travelled did not differ significantly. Concerning the reasons given for immobility, 20% of those who did not move from Monday to Friday, it was for a temporary incapacity (ill, pregnant, etc.) and 24% for a permanent disability. For Saturday and Sunday, three reasons of immobility were coded; for the first reason, “no need to move”, 62% provided this reason for Saturday and 74% for Sunday. However, a more meaningful response (incapacity, weather, activity at home, no car or driver available) is given as second reason by 11% of immobile persons, while the third reason provides no additional information. Thus, asking for mobile/immobile over the last 7 days and for a description of the most recent mobile day seems operational for

avoiding soft refusal. This method would be less sophisticated than that proposed by KIM, which relies on the availability of a panel survey.

Finally, for *Facing the Challenges of Transport Survey Methods in the Era of Big Data* (i.e. the topic of the conference), inverse discrete choice modelling seems to be a promising methodology for imputing respondent attributes, which are not directly provided by mobile phones or GPS devices (Zhao et al., 2017).

6. Future research priorities and recommendations

There are some wider general considerations to raise in the context of conducting successful travel surveys more generally, which is highly relevant to this workshop, namely:

- A suspicion of surveys in general, in the age of computer hacking, ‘big brother’ and, who is asking for the information?
- The off-putting effects of ethics, confidentiality, privacy, data protection forms and information, protection or burden?

From this point of view, the group identified a number of new research priorities and policy recommendations that should be explored further and in more detail to support the understanding of:

- Why people refuse to participate in travel surveys;
- How to augment the datasets we already have, in order to better understand who is refusing and how this affects our travel behaviour models and transport decision-making.

A key overarching issue that was discussed, but left unresolved is whether it is better to try to include everyone in standard travel surveys through better sampling strategies, and use of greater incentives, which is expensive, or to use other targeted methodologies to capture the travel behaviour of ‘under-represented’ groups. The following list of recommendations reflects this ambiguity concerning the best approach.

- Use activity/time-use/participation as the focus for recording activities, instead of mobility per se;
- Improve survey instruments: ask about the last 7 days compared to the last time you moved, use longitudinal and panel surveys, supplementary refuser surveys, combined with GPS tracking surveys;
- Include standard questions on why people have been immobile, their barriers to travel, overall travel patterns to capture the difference between immobility and suppressed demand?
- Profile the non-mobile respondents and soft refusers and benchmark against the mobile/participating counterparts in the same area or social group (e.g. have specific surveys on the mobility of homeless people and rough sleepers);
- Proxy responses should be very seriously questioned from an under-reporting perspective, especially for young people ;
- Explore the effect of different survey modes on non-response: cell phones, web-based, gamification, etc. For analyzing surveys on non-respondents conducted with different survey modes, elaborate a methodology for the estimation of correction coefficients allowing to merge them, which should give a better representation of the whole population;
- Use the opportunities offered by technology (e.g. eye tracker software) to detect people’s survey behaviours, e.g. which questions get answered first or skipped, as well as recording who reports first in the household and the order of diary completions amongst household members.

6.1. Policy Recommendations

It was specifically noted that best known practice is a long way from common practices, and that the academic, commercial consultancy and policy worlds are very different places. This raises the need to:

- Communicate to other policy sectors (housing, health, etc.) the important role of transport in wider social participation and inclusion (e.g. introduction of services in slum settlements);
- Recognise that immobility is not always a negative phenomenon, active immobility;
- Set some minimum standards/checklists of survey inclusion protocols, some basic training on sample composition, screening, proxy data recording (e.g. broad and specialised recruitment survey is expensive and it is difficult to get survey companies to take them on).

6.2. Recommendations for the 12th ISCTSC

- Find a way to use the ISCTSC conferences to communicate some protocols and industry standards for dealing with non-response and immobility;
- Review the synthesis of the acceptable levels of immobility within surveys from existing standards of 8% to 12%;
- Have a workshop on the recording of proxy data (especially important with tracker surveys for recording children's travel);
- Reach out to the wider transport research community also considering these issues, e.g. TRB Travel Survey Committee, EUROSTATS Task Force on passenger mobility;
- Maybe have a journal to promote these discussions.

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References

- Ampt, L., Hickman, M., 2014. Workshop Synthesis: Survey Methods for Hard to Reach Groups and Modes. *Transport Survey Methods: Embracing Behavioural and Technological Changes Selected contributions*. 10th International Conference on Transport Survey Methods, Leura, Australia <https://www.sciencedirect.com/science/article/pii/S2352146515003300>.
- Armoogum, J., Bonsall, P., Browne, M., Christensen, L., Cools, M., Cornelis, E., Diana, M., Harder, H., Reinau, K.H., Hubert, J.-P., Kagerbauer, M., Kuhnimhof, T., Madre, J.-L., Moiseeva, A., Polak, J., Schulz, A., Tebar, M., Vidalakis, L., 2014. Survey Harmonisation with New Technologies Improvement (SHANTI). Les collections de l'INRETS, Paris.
- Armoogum, J., Dill, J., 2014. Workshop Synthesis: Sampling Issues, Data Quality and data protection. *Transport Survey Methods: Embracing Behavioural and Technological Changes Selected contributions*. 10th International Conference on Transport Survey Methods, Leura, Australia <https://www.sciencedirect.com/science/article/pii/S2352146515002975>
- Axhausen, K., 2017. How to capture travel? New ideas and results. Presentation at ITS Leeds.
- Bates, N., 2017. The Morris Hansen Lecture: Hard-to-Survey Populations and the U.S. Census: Making Use of Social Marketing Campaigns *Journal of Official Statistics*, Vol. 33, No. 4, 2017, pp. 873–885. <http://dx.doi.org/10.1515/JOS-2017-0040>.
- Bayart, C., Bonnel, P., 2008. Comparison of web and face-to-face household travel survey-application to Lyon case, Presented at the European Transport Conference, Leeuwenhorst.
- Beaumont, J.-F., 2000. An Estimation Method for Nonignorable Nonresponse Survey Methodology. *Statistics Canada, Catalogue No. 12-001 26(2)*, 131-136.
- Bradley, M., Greene E., Spitz G., Coogan M., McGuckin N., 2017. The Millennial Dilemma: Changes in Travel Behavior or Changes in Survey Behavior? 11th International Conference on Transport Survey Methods, Esterel, Canada.
- de Haas, M., Scheepers E., Hoogendoorn-Lanser, S., 2017a. Identifying different types of observed immobility within longitudinal travel surveys. 11th International Conference on Transport Survey Methods, Esterel, Canada.
- de Haas, M., Hoogendoorn R., Scheepers E., Hoogendoorn-Lanser S., 2017b. Traveling Mode Choice Modeling from Cross-Sectional Survey and Panel Data: The Inclusion of Initial Non-response. 11th International Conference on Transport Survey Methods, Esterel, Canada.
- Deville, J.-C., Sarndal K.E., 1994. Variance Estimation for the Regression Imputed Horvitz-Thompson Estimator, *Journal of Official Statistics* 10(4), 381-394.
- EUROSTAT, 2016. Eurostat guidelines on Passenger Mobility Statistics
- Ferreira, A., Bertolini L., Næss P., 2017. Immobility as resilience? A key consideration for transport policy and research, *Applied Mobilities*, DOI: 10.1080/23800127.2017.1283121.
- Haziza, D., Picard F., 2012. Doubly robust point and variance estimation in the presence of imputed survey data, *The Canadian Journal of Statistics, Statistical Society of Canada* 40, 259-281.
- Hubert, J.-P., Armoogum, J., Axhausen, K.W., Madre, J.-L., 2008. Immobility and mobility seen through trip-based versus time-use surveys. *Transportation Reviews* 28, 641–658.
- Little, R., Vartivarian S., 2005. Does Weighting for Nonresponse Increase the Variance of Survey Means? *Statistics Canada, Catalogue No. 12-*

001 31(2), 161-168.

- Madre, J.-L., Armoogum, J., 1998. Weighting or imputations? The example of non-responses for daily trips in the French NPTS", *Journal of Transportation and Statistics* 1(3), 51-63.
- Madre, J.-L., Axhausen, K., Brög, W., 2007. Immobility in travel diary surveys. *Transportation* 34, 107-128.
- Motte-Baumvol, B., Bonin, O., David Nassi, C., Belton-Chevallier, L., 2016. Barriers and (im)mobility in Rio de Janeiro. *Urban Studies* 53, 2956–2972.
- Motte-Baumvol, B., Bonin, O., 2017. The spatial dimensions of immobility in France. *Transportation* <https://doi.org/10.1007/s11116-017-9763-5>.
- Moulin, A., Morency C., Lord S., 2018. Main Factors Related to Immobility among Elderly People, poster: 18-06172 presented at TRB.
- Pizzol, B., Bianchi Alves B., Abrantes Giannotti M., Strambi O., Arbex R., Bruni L.R., 2017. Travel survey tools and methods: challenges on surveys at slums. 11th International Conference on Transport Survey Methods, Esterel, Canada.
- Richardson, A.J., Ampt E.S., 2012. Nonresponse Issues in Household Travel Surveys, *The Canadian Journal of Statistics* 40(2), 259.
- TRB, 2014. On-line Travel Survey Manual <http://www.travelsurveymanual.org/>.
- Zhao, Y., Pawlak J., Polak J.W., 2017. Inverse discrete choice modelling: theoretical and practical considerations for imputing respondent attributes from the patterns of observed choices, *Transportation Planning and Technology* <https://doi.org/10.1080/03081060.2018.1402745>.