

Non-probability recruitment strategies for innovative smartphone-based travel surveys

Survey, Travel behaviour, Non-probability sampling, GPS, App

Pros and cons of non-probability sampling are varied: Cost-effective techniques enable targeting specific population groups, flexibly reacting to changes in sample structures, and increasing participant motivation. Yet representativeness is frequently doubted when the principles of probability samplings are violated. In the City of Dresden, a travel survey was conducted using a tracking app called TravelVu. This article assesses the performance of both broad-based and individually tailored recruitment strategies, accessing different resources (e.g., news, social media, local ads, printed materials).

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An important basis for urban and transport planning are (household) travel surveys. They provide information on how a transport system with all its interacting modes is currently used and, when repeatedly conducted, which trends are emerging over time.

One of the main challenges facing large-scale travel surveys is the fact that response rates are declining – this can be observed in Germany and beyond. Consequently, risks of selectivity as well as costs and efforts for obtaining high-quality data increase [1].

In addition, innovative tools such as smartphone apps have been coming to the foreground which create new possibilities for data collection via GPS-tracking. Unlike previous data-collecting methods, tracking apps collect data in real time, lowering the overall respondent burden and offering quality framework for a longitudinal survey design [2, 3].

In light of growing interest in new data-collection methods and their integration into traditional survey designs for enhancing data content, a further question arises: Do more targeted sampling and recruitment strategies exist for obtaining adequate sample sizes within an acceptable quality and cost range? Non-probability samples offer various promising approaches such as in-street recruitment, distribution within workplaces, and the use

of social media; yet they also entail challenges regarding systematic sample losses, representativeness, and sample bias [4].

Compared to other fields of research, there is minimal experience in applying such non-probability sample methods to traditional travel surveys [4]. Following up on this, the thesis – submitted to the European Friedrich-List-Prize 2020 – conducted a major travel survey in the City of Dresden (managed and supervised by the TU Dresden), with a digital travel survey app called TravelVu and a non-probability recruitment concept. The goal was to learn about the performance and effects of different recruitment approaches in terms of sampling composition, costs and survey response. Embedded in a research co-project named “Travelviewer – data for low-carbon sustainable transport systems” financed by EIT Climate-KIC, specific travel surveys were conducted in three other European sites, demonstrating the use of TravelVu and testing new means of recruitment.

Non-probability sampling in market and public opinion research

Particularly in market and public opinion research, non-probability sampling has the critical advantage of producing cost and expense savings in comparison to regis-

ter-based sampling. However, certain sample biases may occur as this method does not apply assumptions of probability theory and sampling errors [5].

Non-probability sampling allows for a less-restricted selection of participants, often removing the need for a sampling frame, such as a register of residents. However, this means that the probability of each case being chosen from a target population is not known (it may even be zero). There are five common non-probability sampling methods according to type of selection, likelihood of representativeness, extent of sample control, and overall cost and effort [6, 7]:

- **Quota:** Sampling based on various quota variables, assuming their variability is the same as in the population
- **Purposive:** Sampling by using personal judgement to select cases that will best enable to meet the research objectives
- **Snowball:** Sampling by asking one respondent to establish contact with other potential (hard-to-reach) respondents
- **Self-Selection:** Sampling by allowing each case to identify its interest to take part in the survey – often a crowdsourced task with mutual benefit (see also [8])
- **Convenience:** Sampling by haphazardly selecting those cases that are easiest to obtain

Recruitment concept for an app-based travel survey

Developed by the Swedish company Trivector, TravelVu enables users to GPS-track their everyday movements and activities in a personal timeline. Learning algorithms suggest modes of transport and types of activity that can be traced in an interactive map. Travel characteristics can be adapted with several editing functions available through the app. For survey data, each travel day must be confirmed. Additionally, gamified push-messages motivate users to correct their data. In doing so, participants receive a summary of their trips in distance and time.

The desired sample target for this study was 1,000 individuals, selected from all relevant population groups within Dresden. From 14 Oct. to 24 Nov. 2019, anyone predominantly located in the city could participate. Due to legal regulations, respondents had to be 18 years or older. Potential participants were asked to answer an in-app questionnaire on socio-demographic attributes and to record their travel behaviour for at least seven days.

The survey was called “Dresden in Bewegung” (Dresden in Motion), promoted with “Towards climate-friendly urban transport by app”, encouraging the contribution to a unique data basis for a better and more sustainable urban transport in the future. A non-probability sampling approach was used with a two-stage design, combining various sampling techniques:

- First, *haphazard sampling* was used to reach the advised overall sample size, including mainly crowdsourcing and convenience sampling as well as techniques like snowball sampling.
- Second, during the *dynamic sampling phase*, systematic selection was used to address specific, underrepresented groups and to minimise the risk of skewness. This was mainly a combination of purposive sampling

and quota sampling as a comprehensive method for sample monitoring (age, gender, and post codes).

As a part of the recruitment concept, resources were accessed for spreading the survey via various communication channels. With aspects of participant motivation and technical support included, a broad-based and individually tailored recruitment concept was formed:

Project Webpage: Available in German and English, this page provided information on how to participate as well as details on how to use the app and contact the technical support.

Press Releases: In cooperation with the TU Dresden and the City of Dresden, two press releases were issued, to which several news media outlets responded (crowdsourcing).

Social Media: A Facebook project page was set up to attract new participants as well as inform and motivate active ones through video posts explaining functions of the app, notices on the support, or posts on survey progress (crowdsourcing). These were shared by various persons, institutions, an action group (snowball sampling), and distributed throughout Facebook groups (convenience sampling).

In the second survey stage, Facebook and Instagram ads were applied (purposive sampling) to target underrepresented groups regarding age and city districts.

Local Media: A short promotional ad was shown on screens inside the Dresden tramcars, which was additionally broadcasted on an online TV channel (convenience sampling).

Project Ambassadors: Two external supporters in particular contributed to the distribution (crowdsourcing): The City of Dresden spread the survey via its company mobility management e-mail list; the survey was also put on the Department of Transport Planning website.

The TU Dresden utilised two student e-mail circulars and the monthly student newsletter to spread the survey. Both supporters also promoted the survey on their own social media channels.

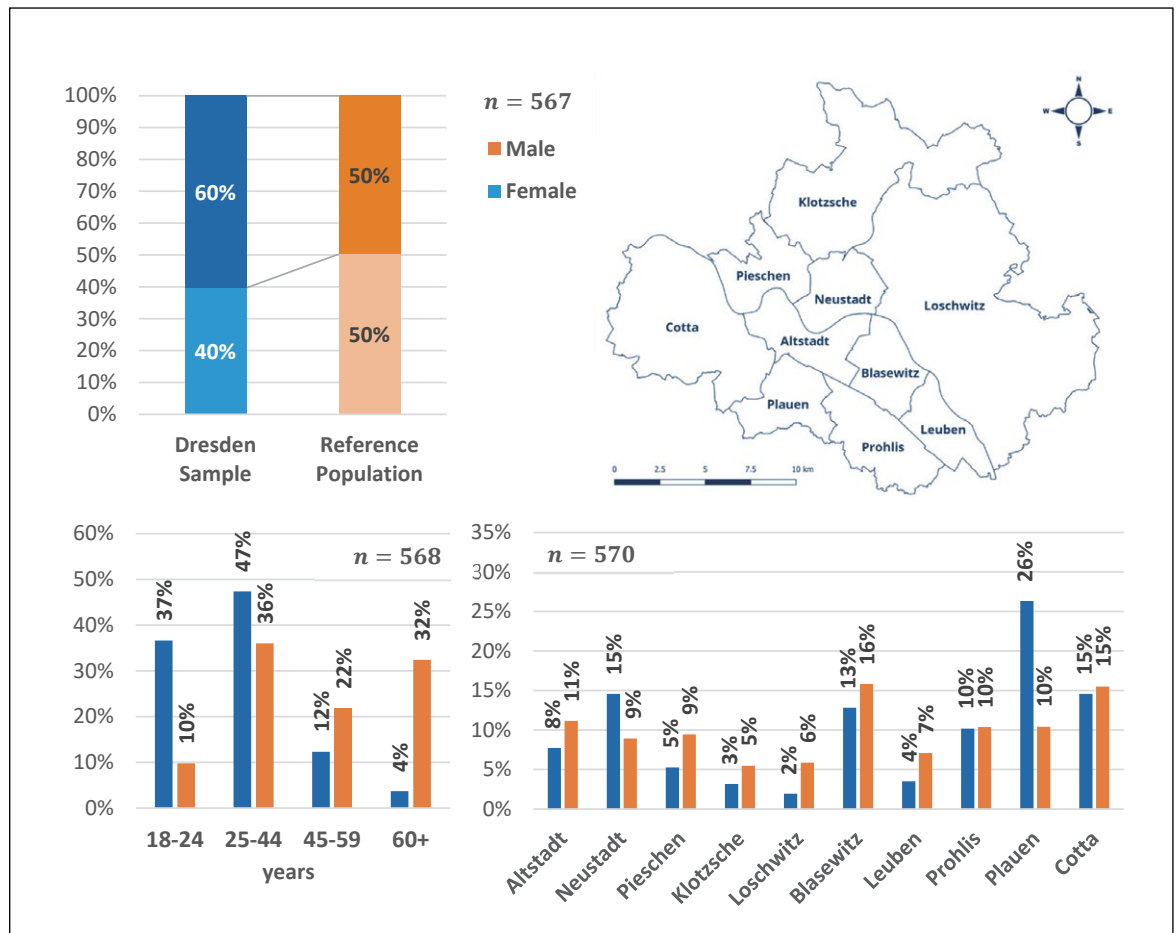
Printed Material: Posters were hung at specific points in the city, and brochures and post cards were displayed and handed out in the city centre as well as at the weekly market. The elderly were primarily targeted during this process (convenience & purposive sampling).

In the second phase, these were additionally distributed to mailboxes along randomly selected routes in underrepresented districts (quota sampling and random route).

Results

During the course of the survey, there was a certain dropout of participants: 1,032 persons joined the survey, of which 941 answered the background questionnaire and 871 respondents recorded their trip information. By confirming travel days, a net sample of 618 participants contributed with travel behaviour data. With only 30 percent further dropout, those that remained collected data from seven days or more. This resulted in nearly 8,500 confirmed travel days, with an average of 13.7 days corrected by the participants, corresponding to a median of 10 days.

Figure 1: Dresden net sample composition compared to register data from September 2019 Register Data: [9, 10]



For analysis, only the data from participants living inside the city (by post codes from the questionnaire) was used; this makes it possible to draw comparisons on register data. Figure 1 shows the distribution of age, gender as well as across the city's districts:

The sample consists of a higher share of young and a clearly low share of elderly people compared to the city's register data from September 2019. However, users are more evenly distributed across the ten city districts. Regarding gender distribution, men are overrepresented to some extent.

Participants also stated how they were made aware of the survey, which makes it possible to assess the recruitment process itself. The access modes most often mentioned were the TU Dresden e-mail circulars (42%), followed by news (14%), and Facebook (10%), but also word-of-mouth advertising was referred to quite often (9%). Social media ads and print distributions had observable precise and group-specific effects, especially through random routes. Platforms such as Instagram and Twitter as well as the ads shown in the tramcars were mentioned the least.

When calculating the cost effectiveness of the recruitment, costs were related to the number of net participants (see figure 2).

With reference to the net sample of n = 618, a cost of EUR 14.73 per participant was calculated. This is about a quarter less costly when compared to "Mobility in Cities - SrV" (a traditional cross-sectional household travel survey in Germany) with about EUR 20.50 per person in

2018. By correlating the net participants to specific access modes, it is apparent that ambassador-based recruitment was the most cost-effective and the distribution of printed material was the least of all.

Discussion and Conclusion

Some recruitment instruments such as the e-mail circulars showed very strong and specific survey success, though they also presented challenges in terms of addressing missing groups. Thus, effects to specific groups need to be considered, and better-performing alternatives should be tested in the future.

The question remains if smartphone-based tracking, combined with non-probability sample recruitment, is a suitable survey method for elderly people - at least for Germany in 2020. In future applications, possible solutions could be, e.g., specifically confining the population to be addressed, providing additional "traditional" survey modes, or offering intensive support for elderly people during recruitment and data collection, eventually supplemented by a random sample.

In conclusion, sample representativeness is a core quality criterion of traditional (household) travel surveys and a necessary prerequisite for making this data applicable for practical transport modelling and planning. This issue needs to be at least critically discussed and reflected towards the objectives of a travel survey. However, even if non-probability sampling strategies risk the potential for bias, they bring valuable advantages to recruitment in terms of flexibility, reactivity, and cost

	Amount	Subtotal	Costs per Participant Netted by Access Mode
Costs (including related working hours)			
Press Releases		161.00 €	1.63 €
<i>Writing and Coordinating with Ambassadors</i>			
Social Media		1,640.00 €	22.47 €
<i>Facebook Page Setup, Creating Posts and Ads</i>			
Ads in Local Media		380.00 €	76.00 €
<i>Public Transport TV</i>			
Ambassadors		81.00 €	0.22 €
<i>Preparing Material for e.g. E-mail Circulars</i>			
Printed Material		3,120.00 €	183.53 €
<i>Post Cards: Design, Display & Random-Route Distribution</i>	4.000	1,300.00 €	
<i>Brochures: Design, Display & Random-Route Distribution</i>	2.000	1,150.00 €	
<i>Posters: Design & display</i>	100	670.00 €	
Project Webpage		661.00 €	
<i>Setup and Maintenance</i>			
Non-recruitment working hours translated to costs		3,060.00 €	
<i>10-week period (preparation phase: 4 weeks; data collection: 6 weeks)</i>			
Total		9,105.00 €	
Total Costs per Net Participant	n = 618	14.73 €	

Figure 2: Calculation of survey costs including respective working hours

effectiveness, and may increase overall participant motivation – especially in combination with a user-friendly and appealing app design. As an area of future research, comparability of mobility patterns gathered by traditional (household) travel surveys and GPS-based data collections needs to be studied in more detail. ■

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