Units of Random Sampling, Units of Analysis and Weighting Responses

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Running headline: Units for Sampling, Analysis and Weighting

The total number of words in the article: 5500

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Abstract

Survey research articles appear in the literature with inadequate or almost no information on survey procedures or on the preparation of data for use (e.g. creating weights for making estimates for different populations). Failure to report adequately on the population sampled, on sampling and on weighting of data can hide critical flaws in research. For example, wandering around interviewing people “at random” at a festival does not yield a random sample of visitors. Therefore reporting such data collection as random sampling is misleading. This paper’s purpose is providing guidance on producing valid survey results and on appropriate reporting of survey methodology. It addresses a variety of sampling/weighting issues. Using examples some specific matters are covered for two general types of surveys.

Key words: best practice, random sampling, sampling bias, weighting

Introduction

When research is based on survey data, there may be different perspectives on what information it is reasonable to expect that a journal article about the research will give. One perspective is that there will be adequate information to at least approximately allow an interested reader to replicate the research (for Public Opinion Quarterly see http://www.oxfordjournals.org/jnls/list/poq/instauth/). A common practice is to just describe the survey and any processing of observations, such as weighting, in very general terms. Unfortunately, when a general description does not allow one to know if proper consideration of length of stay or repeat visiting has occurred for estimates, one may have estimates for person-visits or person-visit days when they should be for unique visitors.

This article does not single out particular published articles to illustrate that survey based articles are appearing in which e.g. visitor or party is being used to refer to samples of party/person-visits or days. Citing specific articles could be considered inappropriate by authors, reviewers and journal editors and would not change material presented on what should be done. Furthermore, consistent with other literature, this article is not suggesting that all surveys must be based on random sampling. One can obtain useful information on problems with a service or reactions to an offering from a nonrandom (nonprobability) sample (e.g., see Cooper & Schindler, 2003: 200). For example, a convenience sample can be appropriate for demonstrating that a technique is useful (e.g. Sirakaya *et al.*, 1996). However, it is not appropriate to use most nonrandom sample results to draw conclusions about a population. The specific concern here is that if survey research is supposed to be based on random sampling, the sampling be random and weighting be such that estimates yield valid and appropriate information for meeting the objective(s) of the research.

For research that is supported to be based on random sampling this article focuses on proper identification of population/universe sampled; appropriate random sampling; and weighting to make estimates for the population sampled or to get valid estimates for other purposes. Regarding population one can note that Cooper and Schindler (2003: 179) state that "A population element is the subject on which measurement is being taken." Subsequently, they state that "the definition of the population may be apparent from the management problem or research question(s) but often it is not (p. 186)." This business oriented text gives practical examples and then comments that there may "be confusion about whether the population should be persons, households, or families, or a combination of these." As for random sampling, these authors recognize simple random sampling, in which each member of the population has equal probability of being selected, is a special case of random sampling in which each population element's probability of being selected can be estimated. A venerable text such as Kerlinger and Lee (2000: ch. 8), while stating that a sample is a portion of a universe that may not be representative, may leave the impression that a random sample is one in which at some level (e.g. for strata) "each member of the population or universe has an equal chance of being selected." In contexts such as sampling in a campground (Lucas, 1963), sampling people fishing in an area (Sheaffer, *et al.*, 2000; Sheaffer & O'Leary, 2005), amount of time exposed to sampling must be taken into account in considering the probability of selection of parties or people. In the "generic" length of exposure to sampling (e.g., duration=Δ), a weight of $1/\Delta$ is applied to every observation.

The last paragraph, by omission, is not meant to suggest that one should dismiss "Travel, Tourism …" handbook (Ritchie & Goeldner, 1994) articles such as Cannon (1994) or Hurst (1994). Cannon and Hurst are, basically, overview articles. Also, this

author takes exception to how some ideas in these articles may be interpreted. For example, reliability is not equivalent to quality (Cannon, 1994: 137). Hurst's comments on bias and response rate may lead some readers to consider bias to only be a problem when the response rate is low. As made clear subsequently, this article is concerned with sampling bias which has no relation to response rate. Therefore, understanding different aspects of bias is important to what follows.

A complicating factor in discussing bias is that one finds it used in a variety of ways in the social science literature. A respondent may, e.g., lie or there may less conscious influences on responses of social desirability, acquiescence, recall, cognitive demand effects, response order effects, and survey mode (Krosnick, 1999; Burton & Blair, 1991; Whittaker, *et al.*, 1998; Dillman, *et al.*, 1996). Here the concern is with a sample being biased because of how it is drawn, because of sampling bias. Sampling bias occurs when the sample is not representative of the population from which it is drawn. Using a university or phone directory to draw a sample for a university or a city leads to bias because not all people in the population are listed (Cooper & Schindler, 2003).

How Statistics Canada weights Canadian Travel Survey (CTS) data (Statistics Canada, 1997) brings a perspective to sampling and weighting that one rarely sees in articles in the tourism literature. What is rarely seen is having a variety of weights for making different estimates. In a way what Statistics Canada does is a special case of the kind of use of weighting that Beaman and Redekopp (1990) argue should occur. For example in the CTS data sets on CD, you have one version of the data with both a weight for trips and a weight for person trips. Because, e.g., expenditures should not be totaled for person trips Statistics Canada provides some special files to help see that people do not use weights inappropriately (Statistics Canada, 1997).

The level of detail Statistics Canada or other agencies must supply to actually allow someone to understand weighting of complicated surveys is hinted at by Hurst (1994: 468) for “en route” surveys. Certainly, in a journal article one cannot have all the detail about weighting a survey that is an add-on to a complicated rotating cluster sample of Canadian households, but even for large institutional surveys having adequate documentation can be enlightening. For example, from detailed information on the USA foreign visitor exit survey (“In-Flight Foreign Visitor Exit Survey” see http://tinet.ita.doc.gov/research/), one can determine that Office of Travel and Tourism Industries (OTTI) does not weight in accord with statements by Hurst on what should be done. For example, one finds that in weighting OTTI does not consider number of international passengers on the flights from which they collect data. Rather, it appears they make the assumption that weighting to foreign traveler *entry data* will correct for failing to consider numbers of people sampled from and some other matters such as some sampling not being on the flights. Specifically, OTTI employs a nonrandom sampling scheme that could result in significantly bias estimates. Bias can be significant because of the high reliability of some national estimates. High reliability (small standard error) in estimates arises because of annual sample sizes in the 50 to 100 thousand range. Though estimates made using the In-Flight Foreign Visitor Exit Survey data *might possibly* be unbiased, it is more likely that for some estimates bias will be large compared to estimate standard error. For the survey one simply does not know the magnitude of bias in different estimates caused by sampling bias. So, agencies as well as individual researchers are open to criticism for sampling and weighting practices.

Problem statement and research strategy

Based on what is presented, by the beginning of the discussion section it should be clear that there are misunderstandings about weighting and sampling that are resulting in flawed research. Presumably, a reason for research design problems is a lack of readily available and easily readable tourism research literature on sampling and weighting problems. *This article addresses that gap.*

The research strategy is to discuss two "generic" examples resulting in insights that apply to a wide range of sampling and weighting. The analysis of examples is followed by a brief discussion that provides (1) a general perspective on sampling and weighting issues and (2) a "best practice" perspective on what a journal article about research based on a survey should make clear about the survey.

Analysis

In considering how to structure this analysis it was recognized that for surveys about people's tourism related activities, at least, three general situations existed regarding locations of surveys. Firstly, data are collected from people *of an area* about their activities somewhere. Secondly data are collected from people *who go to an area* about their activity there and getting there. Thirdly data are collected from people *en route* about some aspects of the "trip" they are on. The first class includes "household" surveys such as the CTS. Surveys at destinations with controlled access (i.e., a limited number of entry and exit points that can be monitored) are in the second class along with surveys at areas with uncontrolled access (from urban parks to public lands that can be accessed anywhere along the boundary). It may seem strange that destination specific studies such as OTTI's In-Flight Foreign Visitor Exit Survey, which Hurst (1994) would refer to as *en route,* fall into the second class. However, the USA is a destination with controlled access. The third class includes

surveys such as “intercepting” people on a trail system, along a road system or at specific points in an area where people can wander around. Unfortunately, a reasonably complete exposition on sampling and weighting issues for the three categories would be lengthy. Therefore, it was decided that two “generic” examples with considerations relevant to a variety of tourism survey projects would be presented.

In what follows reference to sampling party-visits or weighting to make estimates for “unique visitors” may initially seem odd. However as one progresses through the examples, it should seem appropriate. Lose use of words like visitors can lead to misunderstandings. In this regard, that repeated visiting influences being able to report on “unique” visitors is not widely recognized in the tourism literature. Tyrrell and Johnston (2002; see also Johnston & Tyrrell, 2003) point out that when repeat visits are considered there is an implicit period in which the visitor is unique. If one is prepared to work with the unique people who visit a destination in a year, one uses the inverse of annual visits, or an estimate of it, to correct person-visits to “unique” persons. If people always visit a location in the same party, *unique party for a year* has a clear meaning and is also arrived at by weighting by the inverse of average number of visits per year (or the expected number). When a person visits a location in different parties, what *unique party* should mean is not obvious. In a similar manner “a party” using a service need not be the “visiting” party.

In the following, when there is reference to unique persons or unique parties a time period is assumed. When parties are sampled and results transformed to unique people based on party repeat frequency, it is assumed that “most” people only repeat in the same party.

Example 1

Consider a destination with virtually all tourist entry/exit controlled. This destination could be a building or even a country; e.g. an historic building with one entrance/exit or the USA. Assume that management of the building or tourism managers in the USA want to know about their visitors. For the building some data might be collected on entry while for foreign visitors to the USA OTTI has data collected on exit. Here only data collection on entry is considered but for both the unit being sampled is person or party-visit not "unique visitors." Take as given that data collection is for a summer. Unless repeat entry, e.g. during the summer is considered, people who make multiple visits in a summer will be over represented. Looking at it differently, an estimated total for persons would be person-visits not number of unique people. You can think of the unique visitor number as the number from an origin that would be estimated using a survey at the origin in which data on number of people in households making any trip to the destination during the time period of concern was determined.

Anyway, for a park, campground or other location that can have visitors flow in and out through a controllable location (controllable entry and exit) during a visit, assume that management wants to get information on the likely reaction of non tour-group visitors to a discount scheme as well as enhance their knowledge about private vehicle visitors. Also, assume that because of big surges in exit and visitors not really wanting to stop for a survey on leaving, data are to be collected by an entry survey that is followed up by a phone or mail out survey. As well consider that because new visitor entry flow varies greatly over time, sampling stints have been scheduled so low flow times are covered less frequently than high volume times. Furthermore, take as given that when data collection is occurring there is coordination between entry

personnel and interviewers. This matters since by linking interviews to an entry census data, an entry log on new non tour visitors by origin, group size by date-time to interviews, interviewers can sample with a “floating” sampling rate. They start another interview on ending one and sampling rate is calculated from the data in the “entry log”. This makes efficient use of interviewers’ time and maximizes data collected. As for details of weighting, someone competent in sampling should be consulted when in doubt.

For this paper the important matter is considering some *particular* weights to use and the units of analysis one can end up with by appropriate weighting. Given one uses entry census data to define weights for data on entering parties, the universe being sampled is new-entry (first entry for the visit) parties. If one accepts a response for average number (υ) of visits a party makes in a year as an estimate of the repeat rate, one can use a weight of 1/υ to transform to unique parties in a year. Recall one is assuming that most party members do not shift from one party to another from visit to visit. Furthermore assuming most respondents give a meaningful υ is open to challenge. While some first time visitors may know they are on a 1-time-only visit, it is questionable to assume that visitors still checking out a destination (Kozak, *et al.*, 2002) have any idea if they will return, much less have any idea about their frequency of returning. Therefore, one really needs to know if guesses at return frequency lead to sampling bias thus to biased estimates.

For regular repeat visitors’ responses like (a) frequency of repeating, and (b) likely reaction to a discount can be collected on entry. They have experience on which to base answers. However, since some visitors will not even know if they are returning until they have completed a visit, consider that there are post trip follow up telephone interviews to some visitors to obtain realistic information on likely

behavior. For these interviews there will a non-response rate (η). Note that questions on likely future visiting are about decision making so some questions can relate to particular party members. Such responses should be for unique people when one wants one vote for one decision maker (e.g. see Beaman and Redekopp, 1990). Saying the number of parties who will use a discount is 70,000 when this is actually the total for party-visits is both incorrect and misleading. If 50,000 decision makers are estimated to be influenced to come more by a discount then that is 50,000 unique parties coming more. How many times they come is expressed in party-visits. Computation of the impact of the discount on revenue involves having and using data to estimate if net revenue would rise or fall because of the discount. Computations will include estimating consumption increase per annum per unique party. Whether this generates enough party-visits thus revenue to compensate for the discount is what management wants to know.

In general terms consider that for the survey being described, for each party there would be a general entry survey weight (*w*) based on correcting to the entry census. For follow up survey responses *w* is multiplied by 1/(υη) to get unique respondents. In this context, if one asked for demographics for phone respondents (e.g., gender, age, origin), one uses a unique decision maker weight to compute a distribution for decision makers. If party composition data are collected for parties, one can use *w* to compute e.g. an age distribution. However, if one wants an age distribution relevant to what is observed in the park, one would use a party-day weight (*w*days)* in tabulating numbers in age-gender groups. To examine party composition as would be determined by an origin survey asking “did you visit in the last year?”, the unique party weigh is the weight to use (*w*/υ). If one wants to see how party composition varies with duration of stay then tables conditional on categories of duration would be created.

Without going into “gory” detail, the paragraphs above introduce some sampling and weighting issues in a way that some readers may not have thought about. Beaman and Redekopp (1990) give a rather striking example of how survey results can be misinterpreted when improper or inadequate units are used in reporting results for Jasper National Park. It can be argued that party-night weighted tabulations of visitor characteristics tend to correspond to a persons “on the street” impression of visitor mix. For the Jasper survey, 61% of use is by Canadian parities. However, in party tips 58.2% of use is by non-Canadians. Is park use dominantly by Canadians? It appears that the answer depend on how you measure use. Such results occurring prompted the suggestion that when you see statements about “the visitors” and “something is distributed” (e.g., origin, activities), one should ask *what the measurement unit is.*

Example 2

The other general class of survey pursued here is collecting data at intercepts within an area. Studies following this procedure involve stopping people at sampling locations such as along a trail system *in an area*; at specific locations in different *activity areas in a park*; at convenient spots along highways *within a geographic area* (e.g., rest or service locations); and at specific locations *in an area* where a public event is being held. Here the interview locations are referred to as intercepts to preserve the disposition that people are being intercepted during their activity in an area. In this article there is no consideration of “wandering” around an airport, event, etc. interviewing people “at random” because the implication that any kind of random sample can be arrived at in this way is rarely *if ever* justified. Cluster sampling is a different matter than wandering around interviewing people in certain geographic areas (Cooper & Schindler, 2003: 196-198; or for an example see Labour Force

Survey sampling methodology www.sc.ca). The key difference between this example and example 1 is that sampling is not at entry/exit points to *the area* (building, park, country) of concern though sampling points could be entry/exit points for facility/service locations within *the area* (e.g. entrance/exit of a visitor reception center).

To avoid repetition with Example 1, one can note that interviews at intercepts could be followed up by phone or mail out data collection. What populations these additional data can be related to generally depends on the populations the data collected at intercepts can be related to. “Populations” is plural because one is not necessarily sampling the same population at all intercepts just because all intercepts are in an area (α). A possible exception to unit depending on populations sampled is when one comes up with a scheme to use follow up (e.g. mail or phone) data on locations visited to make estimates of e.g. unique visitor numbers (e.g. see Tyrrell & Johnston, 2003).

A major difference between intercepting respondents at intercept locations (λ_i) within an area (α) and collecting data on first entry or final exit is that not all people in a party necessarily go to intercept locations, λ_i, together. Yes, some parties may come to α (*the area*) in two vehicles, but it is reasonable to assume most parties come to and leave α together. When a survey includes interviews with parties on a front country trail, at a hotel play area and on the golf course, it is quite likely that may of the parties are not entry/exit parties. Therefore, care must be taken in collecting data at λ_i or asking about locations visited and using this to infer anything about parties. For an entry/exit survey (see example 1) asking locations “the party” visited is not necessarily interpreted as asking locations any party member visited. If it is and everybody did not go everywhere, what is the unit of the answer? To relate entry/exit

data to "use" at a λ_i you really need person by person data on who went to λ_i or on how may times, if visitor flow to λ_i is of concern. A reason for location specific studies is that asking for detailed information on going to multiple locations may yield poor results because of recall problems or because of satisficing behavior when such a request is imposed on a respondent (Krosnick, 1999).

Now, consider: what is the population that is being sampled when one *intercepts* people or "parties" at a λ_i within an α? The *prima facie* answer is "parties"/people who go to these λ_i while in α? Now, if all visitors to α must go to one of the λ_i and *only go to one on a given trip/visit*, one has a very special situation. This situation can occur if one is studying front county camping in a park with several front country campgrounds (campgrounds people come to and tend to stay at for the duration (δ) of their visit). If in a camper study one collects data from campers at randomly selected sites in campgrounds that visitors use for the duration of a visit, you to get data in camper-parties rather than camper-party-nights by using $1/\delta$ as a weight (Lucas, 1963). Asking campers about facilities used in a park, and/or frequency of their use by each party member, and producing a result for party-nights (using a party-night weight) results in meaningless information.

Now, whether a λ_i is e.g. at a point on a trail, at a service/rest area by a road or is at an activity area such as a display or play area, the stream of potential respondents from which a sample is selected for interview can be observed. For a trail, a trail counter may adequately record flow. At entry points to facilities/services counting of new entrants may be part of ordinary activity. Also, video monitoring that does not allow recognition of particular people but allows counting can be useful in determining a sampling rate without "invading" privacy. Automation of counting allows a sampling rate to be estimated/observed without loss of one interviewer to

counting potential people/parties for interview.

Given that a random sample can be collected at each λ_i, it is important to consider the consequence of people going to more than one λ_i in a visit and going to the same λ_i several times in a visit. Add to the picture that some people visit α many times in a year. In concrete terms, you may have a person who visited α five times in a year and in those visits went to λ_i 12 times. Somebody else who visited α five times in a year may not have visited λ_i or may just have visited it 1 or 2 times. Now, one has seen a special case where sampling from campgrounds yields valid and presumably useful results. In fact, if all front country campgrounds with party sites (i.e. excluding group camping) were sampled in the situation described, one would have a random sample in party-site-nights that can be weighted to represent the universe/population of front-country camping parties. However, if all sampling locations are on trails and one selects the λ_i so all trail users have a chance of being selected in a sample (go to one or more λ_i), then all trail users are being sampled, in a way. However, the population has some respondents with the probability of selection of the one λ_i they go to while other respondents may have (a) probabilities for multiple locations on one day, (b) probabilities for other days on a trip, and (c) probabilities for days on other trips.

A complicating factor with “intercepting” is that when selected a person may have no idea how many more sampling points they will encounter. One must doubt a respondent’s capability to remember λ_i passed previously and, e.g., their capability to guess at λ_i to be passed yet in a year. This suggests that aggregating over λ_i, even when they are one type of facility service, produces meaningless results except in special cases (e.g. front country camping). Furthermore, unless λ_i are final exit points for facilities/services, any experience data collected will be on an incomplete

experience so follow up by mail or phone would be necessary to know how a current experience turned out. In other words for many facilities/services in a park, if one is interested in general information on facility service use, a more efficient strategy than stopping people at λ_i can be contacting visitors at or after final exit. When a λ_i may not be remembered or one wants to encourage recall about it, collection of data at a λ_i may be necessary but then one is not dealing with sampling users of α but rather users of λ_i. One is treating λ_i as an area (α).

Finally consider that the λ_i are not the same kind of facility/service. If one can calculate a weight for each sampling location, is it reasonable to produce aggregate results for all sampling units? The answer relates to reporting on how many pieces of fruit you have because you have grapes, apples and mangos and do not feel right about calling apples mangos. Realistically, what does management learn by having a sum of person nights of camping, person-day exits from the information center and person-day intercepts on a trail. Except in special cases such as identified for camping above, aggregation over λ_i is meaningless. Therefore, except in special uses, surveys of λ_i should each be planned separately with their own objectives guiding research design.

Discussion

General considerations

As the material cited early in the paper indicated, knowing what population to sample can be obvious but may not be. As illustrated, one may sample person/party/group-visits because this is feasible and use weighting to produce results for person/party/group-days or for person/party/group. Recognizing that a sampling frame relates to one population but that data for one population can sometimes be

used to make estimates for multiple populations (e.g. mentioned for Statistics Canada and in examples) is important to research planning. Clearly stating what population is sampled and justifying weighting to appropriate units of analysis should be a part of rigorous presentation of research. In fact, having the right statistical tests matters little when units of analysis are incorrect.

From what has been presented one can see that the problem with some survey research is that what planners of the research see as reasonable, under examination can be found to be unreasonable *or to not necessarily be reasonable*. Regarding "not necessarily be reasonable", one can look at potential problems with estimates made using the In-Flight Foreign Visitor Exit Survey as a case. Estimates *may be unbiased but might not be.* Sampling bias is to be expected when a nonrandom sample is treated as a random sample. Maybe some justification for In-Flight Foreign Visitor Exit Survey estimates being unbiased can be developed in spite of nonrandom sampling. Still, in terms of tourism research actually being scientific, one should know if sampling was random or not. If it is not random the consequence of nonrandom sampling on estimates should be assessed *when these are to be treated as valid and accurate*.

What an article should make clear about a survey

Cooper and Schindler (2003: 659) refer to a technical report on research as being written for an audience of researchers. They maintain that it should contain "sufficient procedural information to allow others to replicate the study." Kerlinger and Lee (2000: 570) in commenting on the experimental versus the nonexperimental method state: "Replication is always desirable, even necessary." The Public Opinion Quarterly (POQ) in its Notice to Contributors makes clear the importance that is placed on

documentation that allows for survey replication by making “at least approximate replication” a requirement (http://www.oxfordjournals.org/jnls/list/poq/instauth/). If survey research is not of such a nature that, in effect, it can be replicated, there is clearly a problem with the research. Therefore, based on what has been presented, it seems reasonable that for publication a best practice be that tourism journal articles provide documentation allowing “at least approximate replication.” In fact, it is suggested that tourism journals adopt the “approximate replication” correction as a requirement for publishing a survey research article.

Conclusions and practical implications

The obvious conclusion from what has been presented is that much tourism research can suffer from validity problems because of flaws related to sampling and/or weighting. By illustrating some sampling-weighting issues this paper has provided readily usable guidance to tourism researchers in an area where it is needed. The examples were intentionally selected to relate to commonly occurring sampling considerations. This means that what was presented can, in many cases, be readily related to real situations and thus of use to practitioners. Given that problems can be averted by a bit more easily readable material being available, this article has served its purpose.

Finally, the paper has set a context for raising the matter of what a journal article based on random sample survey research should make clear about the survey. It seems reasonable that a best practice of the *description of research methodology being adequate to allow approximate replication* be adopt with the caveat that authors adhere to the best practice if they want their survey based articles published.

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