Probability Sampling - A Guideline for Quantitative Health Care Research

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Summary

This essay discusses factors considered by researchers when developing a sampling plan including the frame, sampling unit, sample size, target population, precision, and stratification. The sampling methods of probability, both simple and systematic were also defined and compared on their utility for sampling populations. The usefulness of sampling as applied in a quantitative survey study is illustrated by evaluating an article using the characteristics of comprehensiveness, probability of selection, and efficiency.

Keywords: Probability Sampling, Quantitative Research, Sample Size.

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Introduction

Sampling has received varied definitions by major authors on social research methods. It has been defined as "the process of selecting a smaller group of participants to tell us essentially what a larger population might tell us if we asked every member of the larger population the same questions" (1). A more direct definition is the method used for selecting a given number of people (or things) from a population (2). The desire to draw inferences about a large population from a subset of that population is the main concern for a researcher. Therefore, the researcher must ascertain that the sample truly represents the population by using strategies of selecting an appropriate sample that address bias and possible distortion of data (3).

Its success in representing a population depends on how well the sample frame corresponds to the description of the chosen population, the sampling procedure giving each person a known chance for selection and whether it influences the precision of sample estimates. In this way the research results can be used to make generalizations about the entire population (3). The use of a probability sampling procedure offers each member of a population or the sample frame an equal chance of being selected and improves external validity.

Probability Sampling

Probability sampling specifies to the researcher that each segment of a known population will be represented in the sample. Probability samples lend themselves to rigorous analysis to determine the likelihood and possibility of bias and error (2). Random selection is the process of choosing the components of a sample that ensures each member of a population stands the same chance of selection (3,4). The characteristics of the sample are assumed to be similar to the characteristics of the total population it is drawn from. The initial step in choosing a sample, therefore, is to define the sample frame.

Sample Frame

The sample frame represents those individuals who have a chance to be included among those selected in a sample selection procedure (4). Examples of sampling frames include (a) learners enrolled in a graduate school, (b) a city phone directory, and (c) members of a golfing club. It is desirous to have a complete and updated sample frame list that conforms to the target population of study. Population validity is said to be established when the accessible population represents the target population.

It should enable the calculation of an individual's

probability of selection, and include a high number of members of the target population (2,4). Once the sample frame and sample size have been determined, the researcher proceeds to select the sample randomly from the frame. There are various methods of random selection including the use of a table of random numbers, using a lottery procedure drawing well mixed numbers, and computer programs that determine a random selection of sampling units.

Simple Random Sampling

Simple random sampling has been defined as "a type of probability sampling in which the units composing a population are assigned numbers. A set of random numbers is then generated, and the units having those numbers are included in the sample" (5). For example, if a simple random sample of 100 individuals is required from a sample frame of 8,500 individuals (listed from 1- 8,500) , a straight forward selection could be made using a computer table of random numbers or some other generator of random numbers to produce a 100 different numbers within the same range (4). A simpler but more tedious way of selecting a sample randomly is to put all the names or numbers in a hat and draw the sample that way. Despite this being a simple process, simple random sampling is not commonly used by researchers. There are also concerns about its accuracy.

A major risk of random sampling is when some individuals with important characteristics to the study are left out. Such a situation could arise as a result of under sampling or because certain individuals will not be available during sample selection and will therefore, be excluded (1). To mitigate this, systematic sampling may be used

Systematic Sampling

Systematic sampling is a type of probability sampling in which every unit or individual is selected according to a predetermined sequence from a list. The researcher first determines the number of entries on a list and the desired sample size before computing the sampling interval (k) by dividing the size of the population by the desired sample size (5). If the researcher wishes to select a sample of 100 individuals from a list of 8,500 individuals, he or she will divide 8,500 by 100 to generate the sampling interval which equals 85 (3). The first unit is typically selected at random anywhere between 1 and 85 to ensure a chance selection process. Commencing from the randomly selected number between 1 and 85, a sample of 100 individuals is then selected. The attraction of systematic sampling is that the researcher does not need to have a complete list of all the sampling units. Yet, caution is needed when using systematic sampling.

Although systematic sampling is considered a functional equivalent of simple random sampling and is usually easier to use, researchers need to pay special attention to ordering of the sample frame by any characteristic or some recurring pattern that will affect the sample (1). For example, an organization that lists its employees by ethnic origin could create errors of random selection in a study using systemic sampling as random starts at different points may not provide the same representation of the employees. Issues raised by listings ordered by some characteristic or with a recurring pattern could be resolved by reordering the list or adjusting the intervals used for the selection of units (4).

Sample Size

Controversies still exist as to what constitutes the correct sample size for a study. Some researchers disagree with the common practice of deciding sample sizes using specific fractions of the population, tailoring predetermined sample sizes to specific populations, and calculating confidence intervals (4). The size of the target population from which a particular size of sample is withdrawn may not affect how well the sample will describe the population. For example, a sample of 150 people will similarly describe a population of 15000 and 15 million with the same degree of accuracy assuming the sampling procedures and design match (4). While admitting there are many ways to increase the reliability of survey estimates, it is recommended that researchers first analyze a study's goals as a first step on deciding the sample size (4). These observations have obvious implications for inexperienced researchers planning to conduct a survey type study. In an effort to help researchers with sample size estimations, statisticians have developed internet based programs for determining desired sample sizes for populations. The simplicity and ease of access of the online sample calculators have made them popular with researchers. Internet based calculators provide immediate sample size estimations using data from the total number of units in the sample frame and the desired confidence level. For example, assuming a 95% confidence level using a confidence interval of 5, the desired sample size for a sampling frame of 4000 individuals would be 351 according to one online sample size calculator

(6). Arguably this sampling size estimation does not consider the type of the planned research and could lead to unnecessarily large sample sizes in certain situations. Other options besides online calculators for sample size estimations include rules of thumb or general guidelines based on previous research in the field. As a general guideline for selecting a sample size, the following guidelines may be useful for selecting a sample size: (a) sample the entire population when the number is less than 100; (b) 50% should be sampled if the population is around 500; (c) 20% should be sampled if the population size is around 1,500, and (d) beyond a certain point of about 5,000 or more, the population size becomes almost irrelevant and a sample size of 400 is considered adequate (3). In addition, it may sometimes be necessary to oversample to allow for nonparticipation.

Many people do not like to be included in research studies while others often return incompletely answered questions or unusable survey answers. Researchers should always remember that not everyone chosen to be part of a study sample will accept to participate. It has been suggested that researchers include a cushion of alternative participants in the sample to make up for those who refuse, drop out, or fail to complete the instrument (1). It would therefore be prudent to choose a larger sample than needed. Notwithstanding the importance of selecting the correct sample size, a researcher must always remember that the quality of a quantitative survey depends primarily on the selected sampling frame and how the sampling units will be assigned.

Sampling Errors

It may not always be practical or possible to seek information from the whole population. The fact that the sample will inevitably differ from the population from which it was selected is something researchers have to contend with when conducting studies (1). Sampling procedures used in quantitative survey research studies seen in the healthcare peer-reviewed literature often contain methodological errors in the selection of the sampling frame and the sampling units. Quality concerns in conducting surveys arise from poor design or execution of survey research and ineffective reporting (4,5,7). These errors may have ramifications in public health and the broader healthcare literature.

The sampling error is the variable around the true value of what is being measured and is often described by the standard error (of a mean) in statistical terms (4). The standard error is defined as "the standard deviation of the distribution of sample estimates of means that would be formed if an infinite number of samples of a given size were drawn" (4). The confidence interval around a sample estimate is generally accepted as ± 2 standard errors within which range 95% of such samples will fall. The usefulness of sampling as applied in a selected quantitative research study in the public health field will be evaluated next.

Evaluation of a Quantitative Research Article

In their research study titled "Burden of alcohol in the Uganda Police in Kampala District", the researchers wished to determine the prevalence of alcohol dependence in the police force in Kampala, the capital city of Uganda (8). The study used a systematic sampling procedure from the police register by drawing up a list of all police officers from the rank of constable to superintendent of police. A sampling interval of 20 was calculated with the aim of obtaining a sample size of 100 from the police force. The sample selection was completed by randomly picking one officer from the first twenty, and then subsequently selecting every 20th police officer until the list of police officers was exhausted (8). Any officer who declined inclusion in the survey was dropped and the next on the list selected. Although a probability systematic sampling procedure was envisioned by the researchers, a number of flaws in developing the sampling plan are discernible.

Sample Frame Comprehensiveness

The sample frame used in the study was a 'complete' list of the population of police officers in the city of Kampala, numbering approximately 2,300 officers. It can be assumed that eventual findings from the selected sample would be generalizable to the police force - the study population. The three characteristics of a sample frame a researcher should evaluate are comprehensiveness, probability of selection of units, and efficiency (4). The statement underpins the fact that a sample can only represent the sample frame – in this case the police population—that actually had a chance to be selected. It would be important to consider the comprehensiveness of the selection in an evaluation of a sampling approach to determine the number of people left out.

The authors in this study did not indicate if the police register was scrutinized for possible errors. The randomness of the sample selection could be

affected by improper listing of the officers, and in this case, at least a few officers who should have been in the study are bound to be left out of the sample frame. For example, the composition of the police list needs careful evaluation to study the modality of listing of the officers. Are female officers or senior officers listed separately? Such questions could only be answered by scrutinizing how the list was compiled with a view of detecting any clustering of people with peculiar characteristics that will affect the randomness of the selection. The authors do not mention if the police register was scrutinized for any such discrepancies and whether any adjustments were done. A reorganization of the list—especially if computerized—could be used to create a more representative sampling frame.

Probability of Selection

Another concern is the ability of a researcher to know or calculate the probability of the selection of each selected individual. It would not be possible for a researcher to determine a relationship between the sample statistics and the population sampled (the sampling frame) if the probability of the selection of each individual selected cannot be determined (4). One possible way to determine the probability of selection of each individual officer is to examine closely the list of units in the sampling frame of the police officers (8). Such an examination was probably performed but not reported in the article. However, the authors clearly stated that the first respondent was randomly selected by drawing a lottery of the first 20 individuals on the list. Another point to find out the probability of selection would be during data collection as incidences of double entry into the list could be determined and corrected.

Efficiency

The usefulness of the sample would also be determined by the rate at which members of the police force can be found among those in the sampling frame, a characteristic of a sample frame referred to as efficiency. It could happen that sampling frames sometimes include units or individuals who are not part of the target population. The importance of revealing to the readers of a research paper the individuals who were and those who were not given a chance to be selected has been stressed as the ability to generalize from a sample depends on the sample frame (4). Moreover, it is also important to find out any distinctive attributes of those omitted. For example, during the data collection stage the researchers might discover that a number of police officers have recently been recruited into the police force or transferred from other parts of the country. These new officers may not have the characteristics or behavior patterns of the target population of officers and could be excluded by selecting the next unit in the sample frame. Another possible selection issue could arise if the officers who declined participation and were replaced were more inclined to consuming more alcohol, had something to hide, or simply avoided an embarrassing interview.

Sample Size Determination

The optimum sample size has a relation to the type of planned research. The total number of police officers in the police force list (sample frame) was reported as approximately 2,300 individuals but the authors do not elaborate on how they arrived at a sample size of 100 participants (8). Using a suggested guideline, the estimated sample size should have been 20% of the total number of officers, about 460 (3). It has also been suggested that one should have 100 observations for each major subgroup in survey research and 20 to 50 for minor groups (2). Using the online sample size calculator, a sample size of 329 was derived for this study. The small sample of 100 selected by the authors may limit the generalizability of the findings to the whole Ugandan police force or the general population. Yet, the sample size and population size may not often be correlated as generally believed (4). Assuming the online sample calculator has yielded the correct sample size, the sampling interval could be calculated by dividing the sample frame with the sample size. 2,300 divided by 329 which would yield 6.99. Therefore, the correct sampling interval should have been every 7th officer on the list and not every 20th officer as calculated by the authors.

Rules of thumb can be used to approximate the sample size, but the practice may not be universally accepted by researchers. It has been suggested that new researchers should use approximations to get a feel for sample sizes (2). The amount of variability on the dependent measure within the sample determines the ability to detect statistically significant differences (2). Researchers generally agree that larger sample sizes have less variability but are more costly. Therefore, there is a need to determine the optimal sample size that will take variability into account and still be sensitive to detect statistical significance. The authors probably used a faulty rule of thumb technique to

determine their sample size as the sample size is not congruent with the results calculated using the commonly used sampling size estimation techniques. The possible under sampling that resulted could have affected the variability in the dependent measures and affected the sensitivity or invalidated the statistical tests of significance.

References

1. Glicken, MD. Social Science: A Simple Guide. 2003. Pearson Education, Boston
2. Mertens, DM. Research and Evaluation in Education and Psychology: Integrating Diversity with Quantitative and Qualitative Approaches (2nd ed). 2005. Thousand Oaks, CA: Sage Publications
3. Leedy PD, Ormrod JE. Practical Research: Planning and Design (8th ed). 2005. Upper Saddle River, NJ: Prentice Hall.
4. Fowler FJ. Sampling. Survey Research Methods (4th ed). 2009. 19-47 Thousand Oaks: Sage Publications.
5. Babbie, E. The Logic of Sampling. The Practice of Social Research (10th ed). 2004.178-217. Belmont: Hadsworth/ Thomson Learning.
6. Creative Research Systems. Determining Sample Size and Confidence Levels. Retrieved August 3, 2014 from http://www.surveysystem.com/sscalc.htm
7. Draugalis JR, Coons SJ, Plaza CM. Best Practices for Survey Research Reports: A Synopsis for Authors and Reviewers. Am J Pharm Educ. 2008;72(1):11..
8. Ovuga E, Madrama C. Burden of Alcohol use in the Uganda Police in Kampala District. Afr Health Sci. 2006;6(1):14-20.