Shodhbodhalaya: An International Peer reviewed Multidisciplinary Journal

Volume 3 | Issue 4 | ISSN: 2584-1807 | (https://shodhbodh.com/)

Dated: 22th Dec 2025

Evaluating the Impact of Sampling Methods on the Precision of Data Estimates

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Abstract

Sampling is an important element of research methodology, which has a direct effect on data accuracy and reliability of estimates. The paper examines how various sampling techniques affect the accuracy of estimates of data, covering some of the probability-based sampling techniques like circular systematic sampling, cluster sampling, and multi-stage sampling, and some of the nonprobability sampling methods like purposive sampling, convenience sampling, and snowball sampling. In most cases, probability sampling techniques provide greater accuracy and reliability of the data because they reduce selection bias and nonprobability sampling techniques are cheaper but have a high chances of bias and less accuracy. The study highlights that sampling needs to be aligned with both the study objectives and the nature of the population in order to attain the best and valid results. This paper highlights the significance of the selection of the sampling method in various researches by comparing the advantages and disadvantages of each method. An overview of the trade-offs between cost, time and precision in actual world use of these methods also reflect on the discussion, and offers important insights to researchers in the selection of sampling strategies that are most appropriate in their research.

Keywords: Sampling, Precision, Probability, Nonprobability, Circular, Cluster, Multi-stage, Bias

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1. Introduction

Sampling is an important part of any research study, because it defines how data would be collected and ultimately how the results would be able to be generalized to the larger population. A research design is only as effective as the sampling method adopted, and thus the accuracy and the precision of the data estimates (Lohr, 2010). The proximity of the results to real value is defined by the term precision and, therefore, the appropriate sampling strategy can greatly minimize the possibility of errors and biases (Cochran, 1977).

A sample in research is a section of the population, and researchers use it to give a conclusion about the whole population (Israel, 2013). The main issue is the choice of the sample that will be really representative of the population to guarantee the reliability of the findings (Kalton, 1983). Sampling method adopted should be in accordance with the objectives of the research, the characteristics of the population and resources. Different sampling techniques exist and each has its merits and demerits (Groves and Heeringa, 2006). The choice of probability sampling techniques is usually influenced by the fact that such techniques like simple random sampling, cluster sampling, and multi-stage sampling provide representative and accurate data. These strategies used make sure that all the members of the population have their known and non-zero probability of selection, which reduces bias (Thompson, 2012).

Conversely, purposive sampling, convenience sampling and snowball sampling models of nonprobability sampling are common in situations where purposive sampling is not possible or where the study focuses on specific populations. Whilst nonprobability approaches may be cheaper and more convenient, they are usually associated with trade-offs such as lack of precision and high risks of bias (Patton, 2002). These are especially applicable in qualitative research, exploratory research, in which the main aim is not generalizability (Siegel and Castellan, 1988).

This essay attempts to examine the effect that sampling technique has on data estimates. In particular, it investigates how the sampling approach adopted and the accuracy of obtained data

relate to each other (Hox & Boeije, 2005). Assessing the most common methods of sampling, including probability and nonprobability, this study is expected to suggest the information about how they might influence the results of the research, in particular, in the accuracy and reliability of data (Valliant and Dever, 2018). Additionally, it makes visible the trade-offs of cost, time and accuracy in the choice of the most suitable sampling strategy in different research settings (Fink, 2017).

2. Types of Sampling Methods

The main sampling methods fall into two broad categories, namely, probability and nonprobability sampling methods which have their own benefits and shortcomings that influence the accuracy and applicability of the data. Some of the outstanding sampling techniques have been broadly explained below namely circular systematic sampling, cluster sampling, multi-stage sampling and nonprobability sampling methods.

Circular Systematic Sampling

Circular systematic sampling is a form of systematic sampling; a fixed sampling interval is used on the whole population. After selecting the first unit randomly, the sample selection technique will include skipping a fixed number of units, making sure that a regular interval is used all over the population (Thompson, 2012). The method is especially effective when there is an entire list of people or objects and the researcher is capable of gathering data about a bigger population.

The main merit of circular systematic sampling is that it uses fewer resources than simple random sampling because the latter is time-consuming and expensive particularly in large populations (Groves and Heeringa, 2006). The sampling technique is effective in evenly spread populations and it guarantees the coverage of the whole population. But it can be biased in case there is a periodic trend of data according to the case or if the population is somehow clustered. This may not be very reliable in situations where the population is of cyclic nature like in retail sales or

survey of the agricultural industry (Cochran, 1977). Regardless of this, circular systematic sampling when used on a uniform or evenly distributed population may make more accurate estimates with less sampling error compared to simple random sampling (Lohr, 2010).

Cluster Sampling

Cluster sampling is a method whereby a population is divided into smaller mutually exclusive clusters referred to as clusters which are then randomly selected, and included in the study (Kalton, 1983). The technique is especially beneficial where populations are spatially spread, individual sampling may be too difficult or too costly. An example of this is that in case of studying a national population, the researchers may choose certain areas or neighborhoods as clusters in order to represent the larger population (Hansen, Hurwitz, and Madow, 1953). Once the clusters have been selected the researchers then sample individuals or units within those clusters.

Cluster sampling may greatly lower the cost and logistical barrier of data collection, in especially large-scale studies (Israel, 2013). Nevertheless, the accuracy of cluster sampling-based estimates is very dependent on the homogeneity of clusters. In case the clusters are not homogeneous, that is, there is a high variation inside the cluster, the sampling error may be larger, and hence less accurate estimates will be made (Moors and Huisman, 2015). This is due to the fact that within-cluster variance is assumed to be less than between cluster variance. To counter this, special concern should be given to the definition and selection of clusters. Cluster sampling can be very effective and inexpensive when clusters resemble each other, whereas the clusters differ greatly (Valliant and Dever, 2018). It is important, though, that cluster homogeneity must not overshadow the necessity to have a sufficient population representation.

Multi-stage Sampling

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Nonprobability Sampling

Nonprobability sampling is used when the likelihood of the sample selection of each individual in the sample is unknown or not identical. In contrast to probability sampling, the methods do not adapt to random selection and consequently, they tend to give less generalizable estimates which tend to be biased. Some of the common nonprobability sampling approaches are purposive sampling, convenience sampling and snowball sampling.

- Purposive Sampling: Purposive sampling is also referred to as judgmental sampling, in which the sampling is done based on persons who are felt to be of best relevance to the study. This technique is commonly applied in the qualitative research work wherein the aim is to acquire the insights of particular individuals who possess pertinent knowledge or experiences (Patton, 2002).

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Although this is a cost-efficient and fast technique, it brings about a lot of bias because the sample might not be a true reflection of the entire population (Siegel and Castellan, 1988). The approach is mainly used in exploratory or case-study studies, in which the generalizability is not the main point of focus.

- Convenience Sampling: Convenience sampling entails sampling of persons that the researcher finds the most convenient or that is readily accessible to the researcher (Lavrakas, 2008). As an illustration, a researcher can interview people at a local mall or sample members of his or her social network. Although convenient sampling is inexpensive and easy, it is very likely to be biased because the sample cannot represent the whole population. Consequently, this may affect the accuracy of the data estimates (Tursunbayeva and Sattar, 2020).

- Snowball Sampling: Snowball sampling is applied when the target population is difficult to access, or the population is very specific, e.g., people with rare ailments or groups marginalized (Fink, 2017). The technique is based on the individuals in the existing group being used to recruit others within their networks, in a snowball effect. Even though snowball sampling is beneficial in reaching populations with high inaccessibility, it suffers the same problem as convenience sampling. The sample can be biased in such a way that it includes only people with acquaintances within particular social circles, which restricts the extrapolation of the data (Valliant and Dever, 2018).

Although nonprobability sampling methods are usually used because they are easy and inexpensive, they have the potential to considerably decrease the accuracy of estimates and inject systematic biases into the study. Such approaches are best suited in situations where the intentions are to investigate particular cases or derive hypotheses, as opposed to deriving generalized inferences about a bigger population (Neuman, 2014). In such situations, researchers need to take into account the weaknesses of nonprobability sampling and take into consideration the possible effect on data validity and reliability.

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3. Impact of Sampling Methods on Data Precision

The accuracy of the data estimates- the intensity of the data to represent the true population characteristics- is largely affected by sampling method used. The sampling method also influences the reliability of the research findings because the method used defines the level of representation of the sample. The following gives a deeper discussion on the influence of various sampling techniques on the accuracy of data considering both probability and nonprobability sampling.

Circular Systematic Sampling

Systematic sampling is also varied to circular systematic sampling, which makes data more precise in the case of evenly distributed population. This approach works well especially when the list of units or individuals to be used is complete and the data is considered to be distributed evenly through out the population (Cochran, 1977). The main benefit of circular systematic sampling is that it is more efficient and cheaper as compared to simple random sampling. Researchers can achieve a systematic selection of units by employing a predetermined sampling interval, and at the same time the sample will be representative of the whole population (Lohr, 2010).

But accuracy of estimates may go down in case there are cyclical patterns or cycles in the data. As an illustration, when sales in a survey on retail sales are seasonal, systematic sampling might inadvertently over- or under-sample certain periods, hence inducing bias (Thompson, 2012). Therefore, the technique is ideal when population data are not periodic in nature. In cases where the population is evenly spread out, circular systematic sampling usually gives a more accurate estimate than simple random sampling, particularly where the sample size is extensive (Israel, 2013). However, systematic sampling creates biases when there are underlying patterns and it is also not reliable in such instances (Groves and Heeringa, 2006).

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Cluster Sampling

Cluster sampling is a method that is used to subdivide the population into small groups or clusters and a sample of clusters is taken randomly to represent the whole population (Kalton, 1983). The approach is especially useful when addressing populations that are geographically spread; it would be expensive and time-consuming to sample directly people within the whole population. The accuracy of the estimations made by the clustering sampling technique is very dependent on the internal homogeneity of the clusters. In the case of clusters being internally homogeneous, that is, members of a cluster are similar to each other in the characteristics under investigation, the accuracy of the estimates may be quite high (Hansen, Hurwitz, and Madow, 1953).

Nonetheless, when there is heterogeneity in clusters the accuracy of estimates may be compromised. The reason is that within-cluster homogeneity is not assumed, causing increased sampling error and decrease in the overall estimates (Moors and Huisman, 2015). As an illustration, when clusters are defined by the geographical location and these areas are heterogeneous with regard to the population features, the estimates based on the sample will be less accurate. Nevertheless, cluster sampling may also present a cost-efficient approach to data collection with a decent degree of precision in the instances where clusters are homogeneous and well-defined (Valliant & Dever, 2018). Therefore cluster sampling works very well when there is homogeneity in the clusters, however, attention should be paid in case of diversity among different clusters.

Multi-stage Sampling

Multi-stage is another form of cluster sampling, which is more complicated in the sense that sampling is performed in multiple stages usually starting with large clusters and then reducing to small sub-clusters (Sarndal, Swensson, and Wretman, 2003). This method is most helpful in the case of large scale surveys, with no available or feasible complete list of the entire population. In multi-level sampling, the investigator can first sample large population or regions (e.g., states or

districts), then sample smaller sub-units (e.g., cities or neighborhoods) and subsequently sample individuals within the sub-units (Lohr, 2010).

The major trade-off to multi-stage sampling is the trade-off of cost versus precision. As much as multi- stage sampling is very cheap and easier to manage in regard to the logistical difficulties, it is not usually precise like simple random sampling (Thompson, 2012). A further step in the process may reduce the total accuracy of the estimates, especially when the sub-units are ill-defined, or when they are very variable. However, multi-stage sampling enables the researcher to make good estimates in large and diverse populations that may have resource limitation (Hox and Boeije, 2005). The precision may be enhanced by making sure each cluster or sub-cluster is properly chosen and that there is homogeneity within groups.

Nonprobability Sampling (Purposive, Convenience, Snowball)

The nonprobability types of sampling (purposive, convenience, and snowball sampling) are not based on random selection and, therefore, they are associated with substantial threats of data accuracy and consistency. Such techniques are commonly used where the random sampling is not easy or not possible owing to time or budget limitations or accessibility to the population (Siegel and Castellan, 1988). Nonprobability sampling, however, will tend to introduce greater degrees of bias and reduced accuracy in data estimates because the probability of any one individual being selected is not known or uniform.

Purposive Sampling: In purposive sampling, the researcher carefully chooses the participants he or she wants based on certain criteria that are applicable to the study. This is the technique typical of qualitative research where emphasis is on acquiring the profound information about people who possess specific knowledge or experience pertaining to the issue at interest (Patton, 2002). Though the purposive sampling is appropriate to ensure that the sample addresses the research aims, the sample may not be representative of the overall population, and this aspect may greatly impact the accuracy and generalizability of the data (Tursunbayeva and Sattar, 2020).

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• Convenience Sampling: Convenience sampling is based on picking the people that are most convenient to the researcher or ones that are conveniently located or accessible to the researcher (Lavrakas, 2008). The approach is commonly used in pilot studies or exploratory research where one intends to get preliminary data in a short time. Nonetheless, convenience sample will not be representative because it will include people who are easy to recruit and not necessarily representative of the population. This brings a lot of biasness and diminishes the accuracy of the data (Neuman, 2014).

• Snowball Sampling: Snowball sampling applies to populations that are difficult to reach or study in rare or hidden ones, including individuals with a particular health issue or somewhat marginalized groups (Fink, 2017). In this technique, preliminary participants can provide the researcher with referrals and generate a snowball effect. Even though snowball sampling is valuable when trying to discover previously inaccessible populations, there is risk of it resulting in a homogenous sample, namely, in social networks or traits, thereby limiting the generalizability of results and the chances of bias (Valliant and Dever, 2018).

The net effect of nonprobability sampling approaches to data precision is in general adverse. Although they may be relatively cheap and can be helpful in initial or qualitative research, they lack the accuracy and reliability as the probability-based techniques. Mostly, nonprobability sampling is applied in exploratory research, where the objective is to come up with insights and not particularly accurate estimations concerning a larger group of people (Patton, 2002).

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4. Conclusion

Sampling method is a major determinant of precision and reliability of estimated data used in research. As has been illustrated in the paper, although probability sampling techniques, including circular systematic sampling, cluster sampling, and multi-stage sampling, tend to provide more precision and reliability, nonprobability sampling techniques are common in exploratory research because these sampling techniques are easily achievable and have low costs. Nonprobability sampling techniques, however, are usually associated with the drawback of reduced accuracy and increased biasness that may lead to the invalidity of results. Simple random sampling and systematic sampling techniques are probability sampling strategies that are not only favored when their main goal is a high degree of generalizability but also when the scientists are interested in reducing the bias. Conversely, nonprobability sampling techniques are useful in cases where there are limited resources or where it involves the unreachable population, but the researchers should not disregard the limitations of inaccuracy and inaccuracy. It is important to know the strengths and weakness of each sampling method so as to design effective research to produce reliable and valid results. Finally, scholarship holders should be cautious of trade that exists between cost, time and data accuracy in selecting a sampling method. Although probability sampling types are usually the most suitable ones when the precision of the study is high, nonprobability types of sampling are also applicable with qualitative research or exploration. Additional studies on the design of new sampling strategies that are cost-effective but at the same time do not compromise the integrity of data collection procedures are recommended in the future.

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