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Sampling techniques involving human subjects: Applications, pitfalls, and suggestions for further studies

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Abstract: *The most commonly used sampling techniques in systematic investigations are probability and nonprobability methods. While probability sampling is based on the principle of a random selection of participants in a particular study, non-random selection is the basis of probability sampling. The random and non-random classifications appear to have some potential flaws and are insufficient to represent all sampling procedures involving human participants. Similarly, most authors believe that they use random sampling techniques, although, in reality, they do not use true random sampling. Therefore, the objective of this article is to highlight that sampling techniques can be characterized as true-random, quasi-random, or nonrandom, rather than merely random and non-random. Attempts have been made to demonstrate how inadequate random and non-random sampling classification is, the characteristics of true-random, quasi-random, and nonrandom sampling procedures, and when each sampling procedure is appropriate. How it is conceivable to estimate the characteristics of the population directly or indirectly from the sample has been addressed in light of the selection of sampling units technique.*

Keywords: *True-random; quasi-random; non-random; sampling techniques*

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INTRODUCTION

Sampling is a scientific method used in systematic studies to select units from a target population to represent the entire study population (Berndt, 2020; Singh & Masuku, 2014; Taherdoost, 2016). Researchers usually rely on sampling to estimate the characteristics of the population by studying sample characteristics (Walters, 2021). When researchers select a sample for a study, their primary goal is to understand the features of the entire population from which the sample was drawn, rather than the sample itself. Sampling is essential for a variety of reasons, including cost-effectiveness, increased precision, and efficient use of time, particularly for a large population (Kadam & Bhalerao, 2010; Martinez-mesa et al., 2016). Therefore, to accurately represent the entire study population, the sample should contain all of the features of the population from which it was drawn. However, this is not always the case because all the approaches to sampling do not guarantee the representation of the sample. In systematic research, there are two widely used approaches to sampling: random and nonrandom (Berndt, 2020; Elfil & Negida, 2017; Khaldi, 2017; Singh & Masuku, 2014).

The term "random sampling" refers to a sampling technique where the likelihood of selecting each unit is the same. The sample that is selected at random is thought to be fair and representative of the entire population (Singh & Masuku, 2014). The reduction of sampling error is the main objective of this sampling technique. Non-random sampling, on the other hand, is a sampling technique in which the sample is chosen based on a specific reason

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rather than just chance (Martinez-mesa et al., 2016). Here, the sample will be chosen depending on the researcher's convenience, expertise, or judgment. Bias is seen as a significant limitation of the sample collection process in non-random sampling. The classification of sampling techniques into random and non-random is common in virtually all types of literature related to sampling. Nevertheless, there are several potential pitfalls and issues associated with this classification. This paper, therefore, argues that sampling techniques do not necessarily fall within the category of random and random sampling. Instead, attention should be given to the third type of sampling, called quasi-sampling, which is hardly recognized in statistics and research methodologies. This paper may contribute to the social sciences discipline by enhancing the skills of investigating social phenomena through the advancement of sampling techniques.

While probability sampling is based on the random selection of participants to a study, nonprobability sampling is based on the nonrandom assignment of participants to a study (Ary et al., 2010; Martnez-mesa et al., 2016; Palinkas et al., 2015; Taherdoost, 2016). When it comes to probability sampling, in particular, two key assumptions often underpin its operation. The assumptions are that each unit/person in the population has a non-zero chance of being chosen and that one unit/person’s selection is unrelated to the selection of another (Cohen et al., 2018; Singh & Masuku, 2014). The random selection of participants is based on the assumption that all members of a particular population have an equal chance of being selected (Elfil & Negida, 2017; Kadam & Bhalerao, 2010). When using true-random sampling techniques, because the selection procedure is by chance, each unit of the population from which the sample is drawn has an equal chance of being included in the study. The fundamental principle underlying the use of random sampling techniques is to ensure that the sample is representative of the population it is supposed to represent (Elfil & Negida, 2017; Khaldi, 2017; Sargeant, 2012). Random sampling is likewise important to reduce sampling bias and increase the accuracy of the study (Palinkas et al., 2015; Walters, 2021). This approach is largely common among quantitative researchers (Delice, 2010). Qualitative research, on the other hand, focuses on the careful selection of data-rich participants to make the most of limited resources (Campbell et al., 2020; Palinkas et al., 2015).

As mentioned above, in random sampling, the fundamental principle is that each unit of the population is given the same opportunity to participate in a particular study (Elfil & Negida, 2017; Martnez-mesa et al., 2016). This means that samples obtained using these methods often guarantee that each member of the population has an equal, nonzero chance of being included in the sample. As a result, many authors believe that probability sampling is more accurate in capturing a population's key characteristics, although this is not always the case (Berndt, 2020). It should be noted that the criteria that state every member of the population has an equal and nonzero chance of being selected as a sample is very important and should be highlighted. That is, true-random sampling must provide equal and non-zero opportunities for all members of the study population, and participants must be chosen without violating such random selection criteria. However, not all the so-called random sampling techniques have the potential to produce samples that meet these standards. This could be a reason why Berndt (2020) argues that probability sampling is not as accurate as the authors believe for a variety of reasons, including population size and diversity.

To put it another way, there are some approaches to sampling that are typically described as ‘true-random,’ although they are not necessarily ‘true-random’ but used to assign participants to a study at random. The ambiguity may endure because the border between random and nonrandom sampling is indistinct, and some authors believe that the two methods share many characteristics (Etikan & Bala, 2017). Therefore, the random sampling approach itself should be split into true-random and quasi-random, and the aforementioned sampling techniques would be better presented as quasi-random rather than true-random.

The attempt to classify the sampling techniques into three is not new and dates back to the first half of the 20th century. In 1945, for example, Ralph Cassady tried to present sampling techniques such as pseudorandom, pure-random, and stratified sampling (Cassady, 1945). In non-probability sampling, the sample is chosen under non-random circumstances, and not every member of the population has a chance of being included in the sample. While there are no issues with non-random sampling, the random sample technique needs to be revisited. In particular, some approaches to sampling that are not genuinely random but are seen to be random should be identified and addressed differently. The objective of this article is to revisit the classification of random and nonrandom sampling by (a) demonstrating the distinctions among true-random, quasi-random, and nonrandom sampling techniques; and (b) establishing when true-random, quasi-random, and nonrandom samples are appropriate.

True-random sampling techniques

The random and nonrandom classifications of sampling do not appear to be adequate enough to cover all the sampling techniques. To address this shortfall, classifying sampling as true-random, quasi-random, and non-random appears meaningful. As a result, the following sections attempt to discuss the distinctions among true-random, quasi-random, and nonrandom sampling procedures. To get started with true-random sampling, it is a type of sampling that strictly adheres to the principle of randomization and ensures that every member of the population has an equal chance of being selected. In other words, researchers must start with the assumptions that the sampling frame must be readily available, that each member of the population has an equal chance of being selected without compromising those assumptions, and that the selection procedures must be carried out rigorously according to the set of criteria. In other words, every member of the population must be listed without missing data, and each unit must have an equal chance of being selected in the sample. The basic notion behind this kind of sampling is that a sample selected through this process gives a more accurate population estimate (Singh & Masuku, 2014). This kind of sampling is typically required when a study is quantitative and the results are intended to be directly extrapolated to the entire population (Berndt, 2020; Mulisa, 2022; Sargeant, 2012; Taherdoost, 2016). In particular, while quantitative researchers largely use random sampling, all qualitative researchers use non-random sampling (Gill, 2020; Palinkas et al., 2015).

To recap, true-random sampling is a sampling approach that uses a complete sampling frame, allows every member of the population an equal chance to be selected, and proceeds with the selection accordingly without any compromise. For example, if researchers wish to take a sample of 50 participants from a population of 200, they can select them using the lottery method. If all 50 participants were exactly selected depending on the lottery method and no adjustment was made to the selection by the end, the researchers used true-random sampling. However, the assumption of true-random sampling is violated if certain modifications are made to the sample, such as replacing nonresponding participants. Ideally, a complete population list must be available, and every n^{th} person in every population interval becomes a sample unit in systematic sampling. True-random sampling is when researchers choose every participant in the same way, without making any adjustments, and rigorously follow the n^{th} principle. It is achieved when each unit in the population has an equal chance of being chosen, as in simple random sampling, and when the chance of being chosen is known, as in systematic sampling. However, the precise application of such a randomization principle may not always be feasible for a variety of reasons in social research, including ethics, accessibility, resources, and participant attrition. This type of sampling, on the other hand, is quite practical and more relevant among physical scientists than social scientists.

Conducting true-random sampling appears to be quite essential under some circumstances, whereas it may not be such essential in other circumstances. In particular, it is needed when a sample is a direct representation of the population. In particular, Bordens & Abbott (2018, p. 168) stated that "when you want to apply your findings directly to a population," this kind of sampling is crucial. For example, in a political poll, researchers may survey to predict the precise number of voters who will vote for a particular political party and estimate which party will win the election. Because the sample's finding is directly applied to the entire voters, the researchers must use a true-random sampling to select participants. The key is that the sample should be taken from the voters to whom the researchers intend to generalize using true-random sampling, which is presumed to accurately represent the entire voters. Otherwise, the results of the survey may be skewed, resulting in inaccurate predictions about which political party will win the election. Indeed, Adam (2020) stated that when a sample does not accurately represent the population from which it was drawn, it is unlikely to achieve valid inferences about the population characteristics. Similarly, if the findings of the study are to be applied directly to the population, true-random sampling methods are recommended. The following are the most common approaches to true-random sampling:

Simple random sampling

This is a sampling method that requires the compilation of a list of all units of the population, despite the fact that the population is often small. Researchers select the sample using a variety of techniques based on a complete population list. In a simple random sampling, all units of the population have the same chance of being included in a particular study (Berndt, 2020; Salganik & Heckathorn, 2004). The sample is selected accordingly by giving each unit of the population an equal opportunity to be included in the sample. In particular, this method is believed to be more accurate and should be considered better if the population is homogeneous (Singh & Masuku, 2014). The fundamental assumption is that the desired features are spread evenly throughout the target population. As a result, the results of the sample can readily be extrapolated to the entire population (Delice, 2010). This might also be because researchers that rely on a quantitative approach frequently adopt this method (Sargeant, 2012). Applying simple random sampling methods, the most common approaches are lottery methods and random number methods (Elfil & Negida, 2017).

Unadjusted systematic sampling

If the population is heterogeneous and large in size, it is a useful method to use unadjusted systematic random sampling methods. Unadjusted refers to approaches that strictly adhere to theoretical principles without modification. In this sampling technique, the initial unit of the sample is chosen at random, and the subsequent units are chosen systematically. The researchers choose the units that will be included in the sample based on a predetermined interval, which is commonly regarded as a scientific procedure (Elfil & Negida, 2017). The most significant advantage of this technique is that it is less time-consuming to implement than simple random sampling and tends to choose more evenly across the population (Berndt, 2020). If the population has N units and n units are to be chosen, the sample interval will be computed as N/n, which is commonly known as k^{th}. The first unit is chosen at random from the sampling interval, and the successive units are processed by selecting the k^{th} unit from each sample interval. Every k^{th} is selected directly without replacement to represent the entire population in unadjusted systematic sampling. However, if changes are made to the sample selection procedures and the method's true randomness is violated, the sample's accuracy in directly representing the population will be compromised. Instead, such sampling approaches can be regarded as quasi-sampling, which can be indirectly generalized to the entire population.

Quasi-random sampling techniques

True-random sampling is mostly guided by the availability of complete sampling frames, which does not always work because it can be difficult to obtain a complete sampling frame in some circumstances. As a result, researchers make every effort to ensure a random selection of samples, even if they do not have a complete sampling frame. On the one hand, there is no complete sampling frame, making it difficult to implement, and on the other hand, the researchers make every effort to ensure that the selection is random. Such a technique for sampling is characterized as quasi-random sampling. Nonetheless, once the sample frame is complete, a few of the randomly selected units may refuse to participate in the study. As a result, researchers usually make certain adjustments to random sample techniques, violating the true-random sampling assumption. To demonstrate how widespread this practice is, Martnez-mesa et al. (2016) and Chander (2017) contend that researchers might need to back up at least 10% of the sample size to remedy refusals or nonresponsive sample units. Furthermore, Israel (2003) argues that it can be increased by 30% to compensate for non-response. Although such adjustments are common for researchers to substitute unresponsive participants and replace missing data, it appears that they are not applying the principles of true random sampling. Rather, quasi-random is a type of sampling that is partially random but fails to meet certain criteria of true randomization.

The argument behind the principle of quasi-random sampling is that it cannot be a true representative of the population. The justification is that the sample was selected by different sampling methods that compromised the application of true-random sampling. Therefore, such sampling methods may be more appropriate when the data collected from the sample are indirectly generalized to the population rather than directly generalized to the population. For example, research in social sciences such as business, education, and psychology is usually based on surveys. While this may not always be the case, researchers in these disciplines frequently claim to use random assignment of participants in their studies. The random assignment of participants to a particular study can yield a valid result if the sample size is large enough. However, the concern is whether the findings can be applied directly to the population from which the sample was drawn. In other words, using quasi-sampling is appropriate when the theory of the findings is indirectly generalized to the population. This means that the findings of the sample are theoretically generalized to the population rather than empirically. On the contrary, it necessitates the use of true-random sampling to apply the findings of the sample to the entire population directly. It is also important to determine whether the study's goal is to generalize its findings or advance theoretical understanding. In some social science fields, such as psychology, there is a strong predisposition toward the development of theories rather than the generalization of results to a specific population. In such a context, the quasi-random selection of participants seems very conventional. The accounts of quasi-random sampling techniques will be covered in the following section.

Adjusted systematic sampling

The technique of systematic random sampling is based on the selection of units in a specified gap known as the sampling interval (Martnez-mesa et al., 2016). That means the term "systematic sampling" itself refers to the fact that each chosen unit in the sample has a gap or interval among them. However, selecting each unit in the population while strictly adhering to the interval may not always be possible, particularly if the sample frame is incomplete, the population is large, cases are inaccessible, or nonresponding units exist (Berndt, 2020; Elfil & Negida, 2017; Martnez-mesa et al., 2016). In such circumstances, researchers are required to replace nonresponding or inaccessible participants. This kind of systematic sampling approach is regarded as adjusted as researchers make changes to true-random. This method is similar to unadjusted systematic random sampling in that the investigators select participants to be included in the sample based on a systematic rule and a specified interval. However, for a variety of reasons, researchers adjust the selection of each unit by compromising the k^{th} cases.

Stratified random sampling

Stratified sampling divides the population into homogeneous, mutually exclusive subgroups known as strata (Elfil & Negida, 2017). Before selecting a sample, a population can be segmented into a specified variable of interest that has a value for all units in the sample frame (Taherdoost, 2016). In this type of sampling, all units of the population have a known chance of being selected rather than an equal chance of being selected. If there is indeed a random selection, the chance of being selected based on equal chance is limited to specific strata rather than the entire population. Any of the sampling procedures can be used within each stratum. The sampling procedure may differ from one stratum to the next. In this method of sampling, the strata are chosen using true-random sampling rather than every unit of the population. As a result, this sampling technique is better known as quasi-random sampling.

Combined sampling

A combined sampling technique is a means of selecting samples using more than one sampling technique at a time. Such sampling methods use a combination of random and nonrandom sampling procedures (Etikan & Bala, 2017). Researchers who work on a mixed research approach frequently use this type of sampling technique. In the mixed research approach, Palinkas et al. (2016) argue that whenever the study is large and complex, a single methodological approach is frequently insufficient. As a result, to answer their research questions, researchers employ multiple sampling techniques.

Cluster sampling

Cluster sampling is a method of dividing a population into distinct groups known as clusters (Singh & Masuku, 2014). Because it is impractical to incorporate all the clusters, some of the clusters are selected at random to represent all the entire clusters. Then all units within the selected clusters are included in the sample (Taherdoost, 2016). There are no units from non-selected groups included in the sample, which means they are represented by those from selected clusters. In this method, the clusters are randomly selected, but all units of the population do not have an equal chance of being selected equally. As a consequence, it is unreasonable to regard this procedure as true-random sampling.

Multistage sampling

Multistage sampling refers to the selection of samples that are grouped into various structures using progressively smaller sampling units from each structure. Multistage sampling is a more complex version of cluster sampling and requires structuring the participants into homogeneous subgroups (clusters). Multistage sampling is different from cluster sampling in that it selects a sample from each cluster rather than including all units from the selected clusters (Singh & Masuku, 2014). This type of sampling requires at least two stages. In the first round, large clusters are spotted and framed. In the second stage, units are picked from the identified clusters using any of the probability sampling strategies. Because all units in the overall structure are not allowed to equally engage in the study, this method is better regarded as quasi-random.

Non-random sampling techniques

Unlike methods that use random sampling, in non-random sampling, participants are not chosen for a particular study based on a random technique. Rather, it is used when researchers decide to intentionally include some participants based on a subjective judgment of their suitability (Berndt, 2020; Gill, 2020; Martnez-mesa et al., 2016; Taherdoost, 2016). In such sampling approaches, the possibility of selecting individuals who represent the target population is negligible. Because participants are chosen arbitrarily, it is impossible to estimate the probability that each unit will be included in a sample. There is also no guarantee that every unit has been allowed to be included in the sample. Since this sampling approach rarely yields a representative sample and precluding sample bias is impossible, the findings obtained are not often generalized to the target population (Kadam & Bhalerao, 2010). The justification is that participants who are chosen using a non-random sampling technique are selected intentionally rather than by chance. Unrepresentative samples, on the other hand, might be valuable for certain study objectives and can help answer certain research questions as well as provide new hypotheses (Martinez-mesa et al., 2016). In other words, random sampling yields more breadth, whereas non-random sampling yields more depth (Etikan & Bala, 2017).

Although its findings cannot be generalized, researchers often use nonrandom sampling for a variety of reasons, including convenience, gaining access to chosen participants, or because data gathering is more possible with limited financial access (Etikan & Bala, 2017). Nonrandom sampling is used as an alternative to random sampling when random sampling is not feasible (Ary et al., 2010). Furthermore, there are instances when researchers favor nonrandom sampling, predominantly when they do not intend to generalize the study's findings to the entire population. Although studies that use non-random sampling are frequently useful (Curry et al., 2009; Gill, 2020), the trustworthiness of such studies is determined by the participants' credibility, transferability, dependability, and confirmability (Campbell et al., 2020). Therefore, it is indispensable to explain both the philosophical and methodological motives for selecting particular participants in a particular study. The following are some of the most widely used random sampling techniques in research involving human beings.

Convenience sampling

Convenience sampling is one of the nonprobability sampling techniques in which samples are chosen from the population just because they are readily accessible to the researchers (Elfil & Negida, 2017). They frequently use this technique because it is easy to select the sample, and the sample is not intended to be representative of the entire population. It is widely used by qualitative researchers due to its time and cost-effectiveness, as well as the convenience with which samples are accessible (Taherdoost, 2016).

Judgmental sampling

The phrases judgmental sampling and purposive sampling are treated the same way in this article. It represents a type of non-probability sampling where researchers choose individuals from the population to take part in their studies using their own discretion. If researchers know the composition and characteristics of the population, they will most likely use judgmental or purposive sampling (Elfil & Negida, 2017). The justification is that selecting participants from the population is reasonably decided by researchers who are familiar with the population (Campbell et al., 2020). To put it differently, researchers intentionally choose people who are deemed competent enough to answer research questions for a specific objective (Etikan & Bala, 2017). However, judgment sampling is vulnerable to the researcher's biases and may be even more biased than convenience sampling. This is particularly true if the preconception about the participants' characteristics is incorrect. Regardless of this flaw, judgmental sampling may be quite useful in exploratory research, such as selecting members for focus groups or in-depth interviews. This form of sampling is crucial, especially if the population is diverse and including people with opposing viewpoints is necessary.

Quota sampling

Quota sampling is a type of sampling technique in which researchers are compelled to include members of various mutually exclusive subpopulations to meet the specified number of participants (Johnson & Christensen, 2020; Singh & Masuku, 2014; Taherdoost, 2016). Quota sampling, like stratified sampling, is a technique used when the study population is naturally divided into multiple distinct compositions. When a certain number of participants (quotas) from the sub-populations is required, the researchers deliberately select the required number of participants from each sub-population (Campbell et al., 2020). It is a method of ensuring that the sample size required for each subgroup is met. Unlike stratified sampling, which attempts to guarantee a random selection of participants from each stratum, this type of sampling selects participants depending on who is available and willing within each subpopulation.

Snowball sampling

Snowball sampling is a technique in which research participants participate in the selection of new participants for the proposed study. It is a type of sampling in which one study participant suggests another as a potential participant in the study. In this method, researchers frequently ask each participant to provide them with access to other participants who have the desired qualities (Elfil & Negida, 2017; Taherdoost, 2016). Snowball sampling is a good strategy to use if researchers are looking to find participants that are difficult to reach or who must meet particular requirements (Berndt, 2020).

Table 1. *A summary of true-random, quasi-random, and non-random sampling techniques*

	True-random	Quasi-random	Non-random
Every unit of the population's chance to be selected	Equal	Known	Negligible
Procedures for selecting samples for a study	Purely random	Partly random	Not random
Generalization of findings to the population	Direct	Indirect	Impossible
Some examples of sampling techniques	Simple random, unadjusted systematic sampling	Adjusted systematic sampling, stratified sampling, cluster sampling, and multi-stage sampling	Conventional sampling, judgmental sampling, quota sampling, and snowball sampling

Conclusions

The probability and nonprobability approaches are the two most widely used sampling techniques in research. Probability sampling is based on the random selection of participants, whereas nonprobability sampling employs a non-random sampling process. The classifications of sampling into random and non-random do not appear to be sufficient to accommodate all the sampling procedures currently in use. For example, some authors assign research participants to a study at random and claim to have used random sampling. While it may appear that randomly assigning study participants may be necessary, it is not a sufficient condition for the technique to be random. To compensate for such a shortcoming, categorizing sampling as true-random, quasi-random, or nonrandom appears to be useful. It is indeed worth noting that the random sampling approach is separated into two types: true random sampling and quasi-random sampling. True random selection is based on providing participants with an equal chance of being selected and proceeding with the selection accordingly without compromising it. On the other hand, quasi-random selection is predicated on a known chance of being chosen at the stratum or cluster level rather than at the unit level. As is typical with non-random sampling, there is no possibility of being included in the sample for the participants. Finally, this paper suggests that when the sample is a direct representation of the population, true-random sampling is essential, whereas quasi-sampling is sufficient when the sample represents the population indirectly through theory.

Conflict of interest

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