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Statistical Sampling in Scientific Research: A Practical Guide for Researchers

Abbane Chahrazad
University of Algiers 3 (Algeria), E-mail: Chahrazad.abbane@gmail.com

Abstract:

Obtaining a representative sample is crucial for ensuring the generalizability of research findings**.** Each sampling method has its own advantages and limitations, and the choice of the most suitable one depends on various factors such as the research question, population characteristics, available resources, and desired level of precision. Determining the appropriate sample size involves balancing the trade-off between precision and resources. Increasing the sample size generally leads to more precise estimates but also entails higher costs and time investment. Various statistical techniques and formulas exist to calculate sample size based on factors such as the desired level of confidence, margin of error, and variability within the population. Ultimately, researchers must carefully consider these factors and select the sampling method and size that best suit their study constraints and objectives.

Keywords: Sampling methods, representative sample, research accuracy, sample size, statistical techniques.

Introduction

Scientific research is of great importance in revealing facts and forming theories by which nations develop and move from one stage to another better than them in all their cognitive and scientific aspects, Thus achieving prosperity and progress in all aspects of life, and without scientific research we will be forced to rely only on the authority of others, and scientific research is an objective way to prove a hypothesis, It follows many stages to reach its goals, and there are many scientific researches that use a sample of the population, where the sample provides the required information about the population to be interpreted, because it is not always possible to access all the components of the study, in terms of cost, speed, or accuracy. Therefore, the problem of this study is as follows:

How do we choose the appropriate sample for our study?

in order to answer this question, we divide the study into the following parts:

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First: The sampling design process;

Second: Type of sampling, and select the appropriate sample;

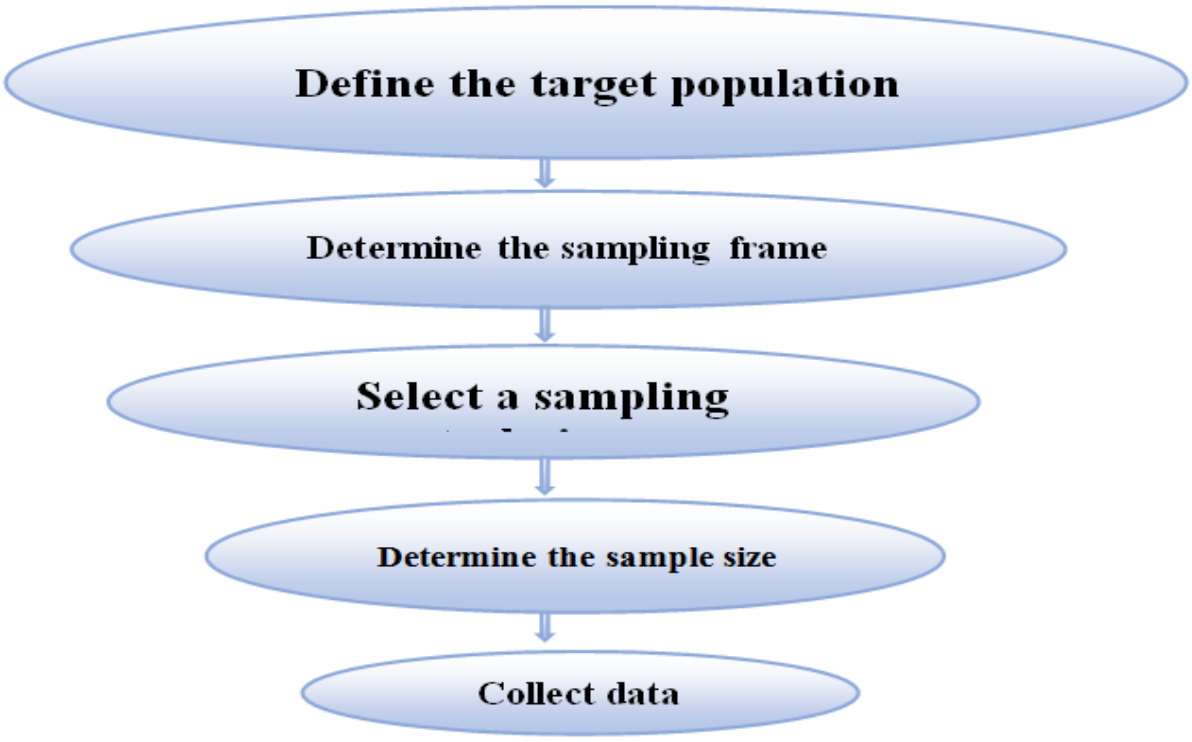
Third: Size of sampling;

Fourth: Advantages and disadvantages of sampling**.**

1. **The sampling design process :**

sample selection goes through several stages. The first stage is defining the target population, which is defined as all the units that the study is interested in. It can be a finite population if it consists of a set of fixed elements, or it can be an infinite population if it is not possible to reach or observe all of its elements, Then the second stage in the sampling process, which is the selection of the sampling frame, which represents an easily accessible section of the study population, from which the sample can be withdrawn, The third stage is to choose the method or technique by which the sample will be taken, then we determine the sample size and collect the required data. **figure 01** shows sampling process steps:

Figure N°01: Sampling process steps



Source: Prepared by researcher.

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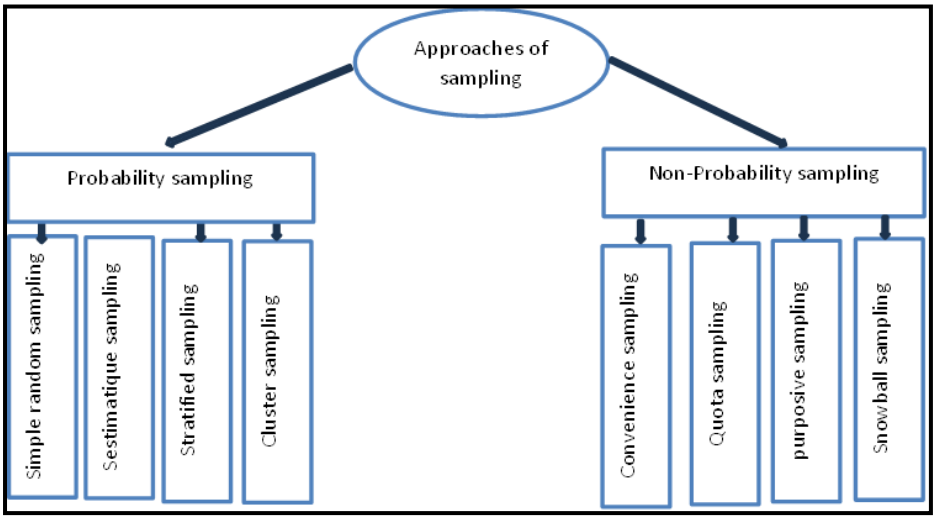
2. Type of sampling:

Samples can be taken in one of two ways, either the probability method or the non-probability method, where in the first case the sample elements are taken randomly, in other words, the selection of each individual participant is based on a predetermined process and not discretion of the researcher, whereas in the second case, participants selection is not made on a statistically random basis, in the other words, the selection of individual participants is based on the discretion and judgment of the researcher, rather than on a predetermined process, **figure 02** shows types of sampling:

Figure N°02: Types of sampling



Source: Prepared by researcher.

2.1. Probability sampling:

We discuss the methods for selecting a probability sample below:

2.1.1. random sampling: Simple probability sampling means that all items have an equal probability of being included in the sample (Teherdoost, 2016, p. 19).

for example: Suppose we want to select a simple random sample of 200 students in a school that comprises 500. Here, we can assign a number to every student in the school database from 1 to 500 and use a random number generator to select a sample of 200 numbers.

- To choose this sample, we follow one of two different methods as follows:
- **lottery method**: In this method, we assign each element a specific number different from the rest of the elements in a sequential manner (1, 2,…, N.) if there

are N units in the population, for example in a population of 100 members, we give number from 1 to 100, right these numbers on in identical cards or slips which are identical in shape, color and size, put discards in a container, shuffle then take in cards on by one, until we obtain the desired sample size.

- **Random number table method**: even though the previous method is very simple and easy to apply whenever the population size is very large it is difficult to adopt this method in such n this case, another method is used, which is a table of random numbers. There are many tables available, such as, yates and fisher's tables, and tippets random number.

2.2.2. Systematic sampling: systematic sampling or interval random sampling. In this method, only the first element is randomly selected, and then the rest of the elements are selected using a fixed or regular time interval until the required sample size is reached. (Deniel, 2011, p. 145).

For example: a production line manager wants to check the quality of products produced on a conveyor belt. The manager selects every tenth product that comes out of the belt to ensure that the quality meets the set standards.

2.2.3. Cluster sampling: The population is divided into subgroups" clusters", then a random sample is taken from each group, then all the selected samples are used in the final sample for the study. It is useful in scientific research whose topics are divided into wide geographical areas. (Deniel, 2011, p. 20).

The cluster sample is selected through the following stages:

- Choose the type of division based on which samples are selected, such as type of company or geographical region;
- Number each of the cluster;
- Choose a sample using random sampling.

For example: suppose we want to conduct a customer satisfaction survey of its retail stores. The company divides the country into regions and randomly selects several stores from each region, all customers who visit the selected stores during a specified time period are given a survey to complete.

2.2.4. Stratified sample: This sampling procedure is sometimes referred to as "quota random sampling", The population is divided into homogeneous stratification, and then a simple random sample is selected from a layer, then the selected samples from the different layers are combined into one sample. (Deniel, 2011, p. 131).

For example: if a population comprises ninety present males and ten females, we may want to balance this skew out by selecting an equal number of male and female participants, this would reduce the representativeness of the sample, so, we divided the population into two homogeneous subgroups (strata) according to gender, then we select the required number from each sample.

- **Steps to select a stratified sample:**
  - We target the population
  - We determine the variables on the basis of which society will be divided into classes, and then we will determine the number of classes used.
  - We create a framework on this basis for all elements in the target population, so the entire population is divided into different strata that will be unique and different from each other, which should cover each element of the population, taking into consideration each member should be in one strata only.
  - We select a random sample from each of the layers

So the difference between stratified sample and clustered sample is in the stratified sample, the researcher divided the population into non-overlapping subgroups based on a particular characteristic, conversely, in the cluster sampling, the subgroups (clusters) should be heterogeneous to ensure that the sample is representative of the population.

2.2. Non-Probability sampling: We discuss the methods of non-probability sampling below:

2.2.1. convenience sampling: Sample members who can be easily reached by the researcher are selected, but this method is criticized for falling into bias because not all individuals are supposed to appear in the selected sample. (Rahi, 2017, pp. 3-5)**,** members of the target population are selected for the purpose of the study if they meet certain practical criteria, such as geographical proximity, availability at a certain time, easy accessibility, or the willingness to volunteer

For example: suppose our study about customer satisfaction in a restaurant, we might choose to only customers who visit the restaurant during a specific time period or on a particular day of the week, rather than selecting a random sample of customers.

2.2.2. Quota sampling: The population is divided into subgroups, then a sample is selected from each subgroup using the convenience sampling method, then all

subsamples are combined to form the final sample representative of the population (Rufai lliyasu, 2012, p. 25).

For example: a hospital wants to conduct a patient satisfaction survey, they use quota sampling to ensure the sample which is representative of their patient population. They set quotas for age, gender, medical condition, and length of stay, and they select participants from their patient database based on those quotas.

2.2.3. purposive sampling: purposive sampling is described as the technique of selecting the number of components sets in such a way that the object depending make approximately the same estimation or percent as the population for those personal characteristics that are currently the subject of data gathering (Thomas, 2022, p. 3).

selective sampling relies on the judgment of the researcher.

For example: suppose our study about refugees**,** and we aim examining the experiences of refugees resettling in a new country: a researcher might use a sample to select participants who have experienced particularly challenging resettlement experiences, such as those who have experienced discrimination of faced significant barriers to accessing services.

2.2.4. Snowball sampling: has achieved increased use in recent years, particularly by researchers conducting observational research and in community studies, conducted in stages, in the first stage a few persons having the requisite characteristics are identified and interviewed, these persons are used as informants to identify others who quality for inclusion in the sample (King, p. 2).

For example: suppose we conduct a study on the homeless in society, it may be difficult to obtain a list of homeless individuals and their contact information. However, if we can get touch with a handful of homeless individuals, they could help refer other homeless people for our study.

3. Size of sample: Determining the sample size is choosing the required number that must be included in the sample to best represent the population.

Optimum sample size must be determined for several reasons, including (kaur, 2017, p. 48365):

- To obtain appropriate analysis
- To provide the required level of accuracy
- To ensure the validity of the significance of the tests

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When sample is too small, the following will happen:

- Even if the study is conducted well, it may fail to answer the research problem
- It may also fail to reveal important effects and relationships between study variables
- It may associate this effect or association imprecisely

When sample is too large, the following will happen:

- The Study will be very difficult and very expensive
- Wasting a lot of time
- Available cases e .g. rare disease.
- Loss of accuracy

According to Sekaran, too small sample size may lead to committing type 1 error, which is the probability of wrongly rejecting a particular finding when to be accepted in fact. Besides, too large sample size is not appropriate because of possible problem of type 2 error, which is accepting a particular finding when it is supposed to be rejected (Blessing, p. 48).

3.1. Sample size in qualitative research: The sample size is estimated based on several factors, including the flowing (Shaheen, Sudeepta, & Ranajee, n.d., pp. 38-39):

- **The scope of the study:** The broader the scope of the research, the more data must be taken. Care must be taken to narrow the topic of study in the initial stage, especially if it is an unfamiliar topic, but not at the expense of neglecting important aspects of the topic of study.
- **The nature of the topic:** When the topic is clear and familiar and the information is easily accessible, we will need a smaller number of interviewees, but if the topic is new and unclear, we need a larger number of interviewers to collect a sufficient amount of information.
- **The quality of data:** Data quality refers to the number of participants required for the study and whether respondents took the time to understand the questionnaire's topics. In addition, the ability of the respondents and their experience about the phenomenon studied also determines the quality of the data.

- **The shadowed data:** sometimes participants along with their own experience discusses the experience of others and how their own experience differ or resembles from others, and why, the information reported about the experiences of others is called shadowed data, shadowed play a significant, role in the qualitative research as it provides the researcher with 'some idea of the range of experiences and the domain of the phenomena beyond the single participant's personal experience'

3.2. Sample size in quantitative research: There are many ways to choose sample size in quantitative research, the most important of which is estimating variance using published tables and using mathematical formulas to calculate sample size

3.2.1. Mathematical derivation: there are many equations to determining the sample size, among them:

- **Krejcie and morgan's equation:** In their article entitled 'determining sample size for research activities' published in 1970, krejcie and morgan proposed the following equation to calculate the appropriate sample size (Robert t & Darly w, 1970, pp. 607-610)

$$s = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2(1-P)}$$

Where ***:***

- **S:** required sample size
- X^2: the table value of chi-square for 1 degree 0f freedom at the desired confidence level 3.841
- N**:** the population size
- P: the population proportion -assume (Steven K, 2012)d to be 0.05 since this would provide the maximum sample size-
- d: the degree of accuracy expressed as a proportion 0.05
- **Thompson's equation:** steven K. Thompson in his book 'sampling' proposes the flowing equation (Thompson, 2012, p. 59)**:**

$$s = \frac{N.P(1-P)}{\left[(N-1)\frac{d^2}{Z^2}\right] + P(1-P)}$$

Where :

- n: sample size.
- N: population size
- Z: confidence level at 95%
- d: error proportion 0.05.
- p: probability 50%.

2.2.2. Estimation of variance: There are four ways to estimate population variance (Adam, p. 92):

- Determine the sample size by following two steps, and use the results of the first step to determine how many additional responses are needed to attain an appropriate sample size based on the variance observed in the first step data.
- Using the results of the experimental study.
- Using data from previous studies of the same or a similar population.
- Estimating or guess population structure with the help of some logical mathematical results.

4. Sample size determination table: the third method for determining the appropriate sample size depends on published tables, as these tables give the appropriate sample size for research based on many criteria

5. Advantages and disadvantages of sampling:

5.1. advantages of sampling (Bhardwaj, 2019, p. 158)**:**

- Save time and money and gives faster results as the sample size is smaller than the whole population;
- Sampling gives more accurate results as it is performed by trained and experienced investigators;
- When there is large population, sampling is the best way;
- Sampling enables to estimate the sampling error, hence, it assists in getting information concerning to some characteristics of the population;
- Study of samples requires less space and equipment as they are small in size;
- When there are limited resources, sampling is best.

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5.2. Disadvantages of sampling (singh, p. 7)**:**

- Inadequacy of the samples;
- Chances for bias;
- Problems of accuracy;
- Difficulty of getting the representative sample;
- Untrained manpower;
- Absence of the informants;
- Chances of committing the errors in sampling.

Conclusion:

those are all important factors to consider when estimating the appropriate sample size for a study:

- **Research approach:** The chosen research approach, whether it's qualitative, quantitative, or mixed methods, can influence the sample size requirements. For instance, qualitative studies often focus on depth rather than breadth, so sample sizes may be smaller compared to quantitative studies.
- **Analytical method:** The analytical methods planned for data analysis can impact sample size requirements. Some statistical techniques may require larger sample sizes to achieve sufficient power or precision.

Number of variables or model complexity: Studies with more variables or complex models may require larger sample sizes to adequately capture the relationships between variables or to ensure statistical validity.

Time and resources: The availability of time, budget, personnel, and other resources can constrain the sample size that is feasible for a study.

- **Completion rate:** Anticipated rates of participant completion or response can affect the necessary sample size. If there's a high likelihood of attrition or non-response, a larger initial sample may be required.
- **Sample size used for similar studies:** Previous research in the same or similar area can provide guidance on typical sample sizes used and help inform decisions about sample size for the current study.
- **Data analysis program:** The software or tools used for data analysis may have specific requirements or recommendations regarding sample size.

- **Nature of the population:** Characteristics of the target population, such as its size, homogeneity, or heterogeneity, can influence sample size considerations. Larger and more diverse populations may require larger sample sizes to ensure representativeness.

By carefully considering these factors in conjunction with the research objectives and constraints, researchers can make informed decisions about the appropriate sample size for their study.

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