



Research Methods & Technical Writing

Lesson 4 - Week 4

Sampling Design

Lecturer: Dr. Msagha J Mbogholi, PhD

Flashback from Lesson 3

- Research design is a framework that includes the methods and procedures to collect, analyze, and interpret data. In other words, the research design describes how the researcher will investigate the central problem of the research.
- Based on the design decisions the overall research design can be split into three components/parts: sampling design, observational design, and operational design.
- Research design can be viewed or described as being one of two perspectives: quantitative or qualitative
- Characteristics of good research design are neutrality, reliability, validity and generalization.
- Variables may be categorical, ordinal or nominal.
- In research variables may be dependent, independent, intervening, moderator, confounded, composite or extraneous.
- Research design approaches may be described as descriptive, experimental, correlational, and explanatory; other literature categorize the approaches as exploratory/ formulative and descriptive/diagnostic.
- The 3 R's of experimental design are randomization, replication and noise reduction (local control).

Content

- Introduction
- Steps in sample design
- Criteria of selecting a sampling design
- Types of sample design



Part 1

Introduction

Introduction

- So far in the course we have learnt different definitions of terms used in research. We have also learnt the significance of the research question/problem and how to go about defining it.
- In lesson 3 we learnt how to go about formulating the research design. The next step is to go and collect data that will solve or shed light on the research problem. However, this is easier said than done.
- Why is this so? Consider the question of trying to determine whether smoking cessation does significantly increase lifespan of individuals. We decide to operationalize the term 'significant' to mean at least 10 years, and we statistically take the average lifespan to be that which has already been provided in existing literature. This appears to be a rather daunting task, doesn't it? Who do we use to investigate this phenomena? My country has a population of about 40 million people. Should I go around the whole country looking for former smokers? Supposing I refine my target population to people who quit smoking for at least 5 years, would that narrow down my target group? Indeed it would, but the population are scattered all over the country and this is a task that requires a lot of resources (manpower, finances, time, and so on). I put it to you that perhaps it is only a body backed by the government (or the government itself) which is able to undertake a study of such proportions.

Introduction (cont'd)

- The other option is to find a way to reduce the size of the target population. One way of doing this is to refine our research problem and target the population of say, one county. However, as a good researcher this should not satisfy you since this was not the initial intention; worse it doesn't cover the whole country meaning the results will be suspect. Another option is to use what we call a sample in research.
- What is a sample? And what exactly do we mean by population? (Mwaikusa, 2015) provides the following simple definitions:"
- **Sample**, this is the finite part of statistical population whose properties are studied to gain information about the whole. When dealing with people, it can be defined as set of respondents selected from large population for the purpose of survey.
- **Population**, this is group of individual person, objects or items from which sample are taken for measurement. For example a population of book, presidents, teachers or students. "
- Based on the above definitions it means that we can now take a sample or samples of our population (people who have quit smoking) for the purpose of our investigation. The act of determining the way in which we shall collect our sample is called sampling; while the strategy used in collecting the samples is called the sampling design.

Introduction (cont'd)

- (Mwaikusa, 2015) also provides a list of advantages that sampling provides in the field of research: “
- The time factor – sample may provide you with the needed information quickly.
- Accuracy of sampling, a sample may be more accurate than the census.
- Reduced cost – it is obviously less costly to obtain data for a selected subset, rather than the entire population.
- The large size of many populations – in some cases the size of the population is extremely large.
- Destructive nature of some studies. In some studies for example quality control studies, the only way to know the characteristics of the sample unit is through destroying them
- In some cases, it is impossible to identify all units in the population. ”



Part 2

Steps in sample design

2.1 Introduction

- “A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher would adopt in selecting items for the sample. The sample design may as well lay down the number of items to be included in the sample i.e., the size of the sample. Sample design is determined before data are collected. There are many sample designs from which a researcher can choose. Some designs are relatively more precise and easier to apply than others. Researcher must select/prepare a sample design which should be reliable and appropriate for his research study.” (Kothari, 2004)

2.2 Steps in sample design

- Kothari (2004) proposes the following seven points to be put in consideration when it comes to sample design:
- Type of universe (environment) - The first step in developing any sample design is to clearly define the set of objects, technically called the Universe, to be studied. The universe can be finite or infinite. In finite universe the number of items is certain, but in case of an infinite universe the number of items is infinite, i.e., we cannot have any idea about the total number of items. An example of an infinite universe is the number of oxygen molecules in a given environment.
- Sampling unit - Sampling unit may be a geographical one such as state, district, village, etc., or a construction unit such as house, flat, etc., or it may be a social unit such as family, club, school, etc., or it may be an individual. (*APA Dictionary of Psychology*, n.d.) define a sampling unit as “any of the elements selected from a population to make up a sample. For instance, if classrooms are selected at random from the population, then the classroom—not the individual student—is the sampling unit.”
- Source list (a.k.a. sampling frame) - A sampling **frame** is a list of things that you draw a sample from. A sample **space** is a list of all possible outcomes for an experiment. For example, you might have a sampling frame of names of people in a certain town for a survey you’re going to be conducting on family size. The sample space is all possible outcomes from your survey: 1 person, 2 people, 3 people...10 or more. (Glen, n.d.)

2.2 Steps in sample design

- Size of sample – refers to the number of items to be selected from the universe to constitute a sample. This is a major problem before a researcher. The size of sample should neither be excessively large, nor too small. It should be optimum. An optimum sample is one which fulfills the requirements of efficiency, representativeness, reliability and flexibility.
- Parameters of interest – it is equally important to determine the specific population parameters that are of interest in the given research investigation; this will certainly have a significant impact on the sampling design.
- Budgetary constraints – costs will play a relevant role in the selection of both sample size as well as the sample type. It goes without saying that you must work within the allocated budget of the research.
- Sampling procedure - the researcher must decide the type of sample he will use i.e., he must decide about the technique to be used in selecting the items for the sample. In fact, this technique or procedure stands for the sample design itself

2.3 Sampling process steps

- Francis (2010) describes seven steps for the sampling process; that is, how to go about selecting a sample:
 - Defining the target population.
 - Specifying the sampling frame.
 - Specifying the sampling unit.
 - Selection of the sampling method.
 - Determination of sample size.
 - Specifying the sampling plan.
 - Selecting the sample.

Notice the order of the steps; sampling method is only determined after specifying the sampling frame and unit, sample size is determined after selecting the sampling method, and so on.



Part 3

Criteria of selecting a sampling design

3.1 Introduction

- When performing sampling analysis there are two costs that are involved; the cost of data collection and the cost of drawing wrong interpretations from the data.
- The two causes of wrong interpretation are systematic bias and sampling error. These two terms are defined as follows:
- Systematic bias is sampling error that stems from the way in which the research is conducted and can therefore be controlled by the researcher. There are three types:
- *Selection bias*: The way in which the participants are selected, causes a biased view.
- *Non-response bias*: A biased view arises, because the people that are willing to participate in your study, are different from the people that do not respond in your study.
- *Response bias*: A biased view arises, because the answers that are given are not in accordance with the truth.
- Source: (*What Is Systematic Sampling Error (or Systematic Bias)? | WorldSupporter, 2019*)
- Sampling error happens when the selected sample is not representative of the population of interest.

3.2 Criteria of sampling procedure selection

- Systematic bias is usually the result of one or more of the following factors (Kothari, 2004):
- An inappropriate sampling frame (it is not representative of the population/universe)
- Defective measuring device – this can include bias in the questionnaire or even the interviewer.
- Non – respondents – inability to sample all the individuals who were included in the sample may result in this bias. This is because the non-respondents had been measured in order to get an accurate analysis.
- Indeterminacy principle – this happens when individuals act differently when placed in observation states. The indeterminacy means that how they behave is uncertain and so the reliability of the results is in question.
- Natural bias in reporting of data – this happens when respondents aren't truthful with their answers, depending on the circumstances and type of questions being asked.

3.2 Criteria of sampling procedure selection

- There are three ways to reduce sampling errors:
- By increasing sample size: Using a larger sample size helps to yield more effective and accurate results as the research becomes closer to the true population size.
- By creating groups to segment the population: Instead of choosing a random sample, create and test groups based on their size in the population. For instance, if people of a certain demographic constitute 30% of the total population, it's important to ensure that your research is based on this variable.
- By knowing your population well: To reduce sampling errors, it's essential to understand your population and be aware of its demographic mix. Delve deeper to uncover the demographics that use your product or service and always target the right sample (that actually matters to your business)."
- Source: <https://www.voxco.com/blog/sampling-error/#:~:text=By%20increasing%20sample%20size%3A%20Using,their%20size%20in%20the%20population.>

3.3 Characteristics of a good sample design

- Kothari (2004) concluded that the characteristics of a good sample design are: “
- Sample design must result in a truly representative sample.
- Sample design must be such which results in a small sampling error.
- Sample design must be viable in the context of funds available for the research study.
- Sample design must be such so that systematic bias can be controlled in a better way.
- Sample should be such that the results of the sample study can be applied, in general, for the universe with a reasonable level of confidence.”

3.3 Characteristics of a good sample design

- Other characteristics of good sample design include:
- **Goal Orientation:** This suggests that a sample design “should be oriented to the research objectives, tailored to the survey design, and fitted to the survey conditions”. If this is done, it should influence the choice of the population, the measurement as also the procedure of choosing a sample.
- **Measurability:** A sample design should enable the computation of valid estimates of its sampling variability. Normally, this variability is expressed in the form of standard errors in surveys. However, this is possible only in the case of probability sampling. In non-probability samples, such as a quota sample, it is not possible to know the degree of precision of the survey results.
- Source: <https://www.vskills.in/certification/tutorial/characteristics-of-a-good-sample-design-2/>

3.3 Characteristics of a good sample design

- **Economy:** Finally, economy implies that the objectives of the survey should be achieved with minimum cost and effort. Survey objectives are generally spelt out in terms of precision, i.e. the inverse of the variance of survey estimates. For a given degree of precision, the sample design should give the minimum cost. Alternatively, for a given per unit cost, the sample design should achieve maximum precision (minimum variance).
- **Practicality:** This implies that the sample design can be followed properly in the survey, as envisaged earlier. It is necessary that complete, correct, practical and clear instructions should be given to the interviewer so that no mistakes are made in the selection of sampling units and the final selection in the field is not different from the original sample design. Practicality also refers to simplicity of the design, i.e. it should be capable of being understood and followed in actual operation of the field work.
- Source: <https://www.vskills.in/certification/tutorial/characteristics-of-a-good-sample-design-2/>



Part 4

Types of sample design

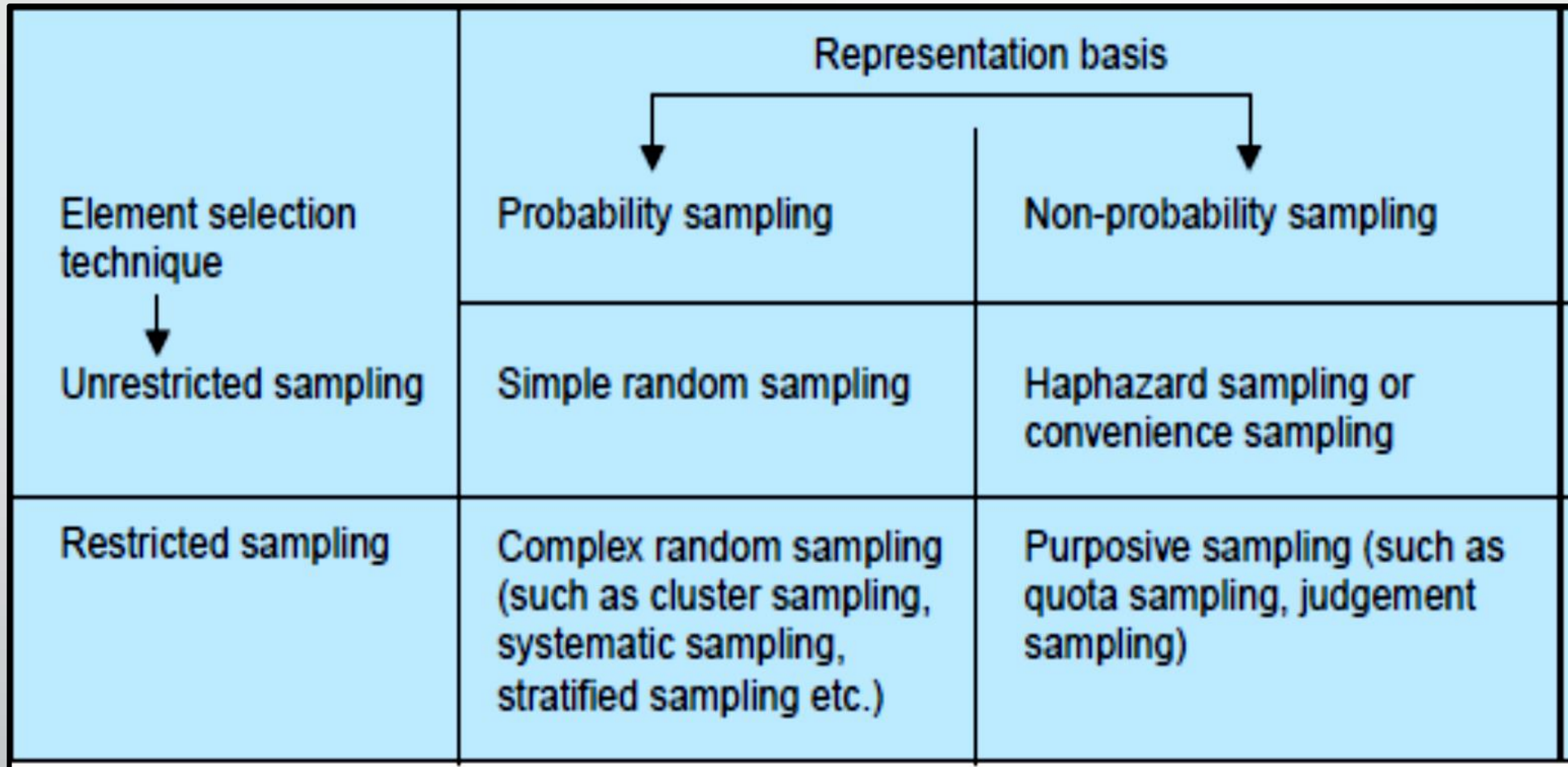


Fig 1. Basic sampling designs (Kothari, 2004)

4.1 Introduction

- Fig 1 shows the way in which sampling designs can be classified. Kothari (2004) provides an explanation:"
- There are different types of sample designs based on two factors viz., the representation basis and the element selection technique. On the representation basis, the sample may be probability sampling or it may be non-probability sampling. Probability sampling is based on the concept of random selection, whereas non-probability sampling is 'non-random' sampling. On element selection basis, the sample may be either unrestricted or restricted. When each sample element is drawn individually from the population at large, then the sample so drawn is known as 'unrestricted sample', whereas all other forms of sampling are covered under the term 'restricted sampling'."
- From fig 1 it can be seen that sampling is either of probability or non-probability types.

4.1 Introduction (cont'd)

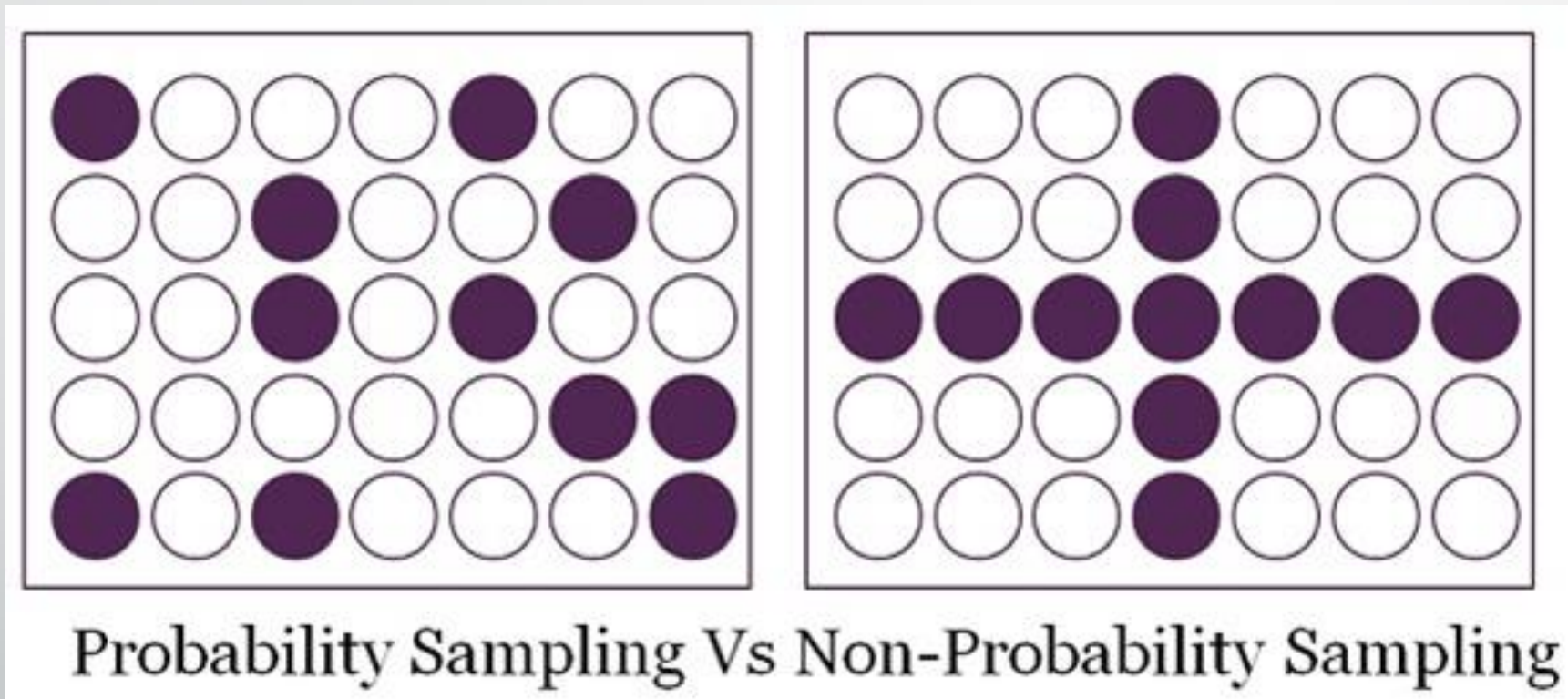


Fig 2. Probability vs non-probability sampling (Singh,S, 2018)

4.1 Introduction (cont'd)

- Fig 2 shows the difference between probability and non-probability sampling. It can easily be noticed that the spotted balls appear to be in random places in the probability box, while they appear to be following some kind of order in the non-probability box.
- “The difference lies between the above two is whether the sample selection is based on randomization or not. With randomization, every element gets equal chance to be picked up and to be part of sample for study.” (Singh, S, 2018).
- In the remaining part of this section we discuss the different probability and non-probability sampling types, with examples where appropriate, to simplify the complex methods.

4.2 Non-probability sampling

- “Non-probability sampling is that sampling procedure which does not afford any basis for estimating the probability that each item in the population has of being included in the sample...In this type of sampling, items for the sample are selected deliberately by the researcher; his choice concerning the items remains supreme. In other words, under non-probability sampling the organizers of the inquiry purposively choose the particular units of the universe for constituting a sample on the basis that the small mass that they so select out of a huge one will be typical or representative of the whole.” (Kothari, 2004)
- Based on the above description it is obvious that there will be some bias using this method; further there is no way of measuring sampling errors when techniques falling under this category are used.
- As Singh, S (2018) describes it: “Outcome of sampling might be biased and makes (it) difficult for all the elements of population to be part of the sample equally”

4.2.1 Characteristics

- The characteristics of non-probability sampling are (Singh, Y, 2006):”
- 1. There is no idea of population in non-probability sampling.
- 2. There is no probability of selecting any individual.
- 3. Non-probability sample has free distribution.
- 4. The observations of non-probability sample are not used for generalization purpose.
- 5. Non-parametric or non-inferential statistics are used in non probability sample.
- 6. There is no risk for drawing conclusions from non-probability sample”
- There are 4 non-probability sampling techniques: convenience sampling, purposive sampling, quota sampling, and referral/snowball sampling.

4.2.2 Advantages

- This branch can be used where no sampling frame (full details of the total population) is known.
- It provides detailed descriptions about the sample in question, meaning if your research is interested in qualitative takeaways, non-probability sampling can provide you with more insights.
- It's quick and cheap to carry out. You only need to invest a small amount of time to gather a sample size you feel is appropriate before you begin your research.
- It does not fall subject to low response rates — a common issue for probability sampling techniques.

Source: <https://www.qualtrics.com/experience-management/research/non-probability-sampling/>

4.2.2 Advantages

- It can be a quick starting point to investigate or explore if there is an issue among a specific audience group or target market, leading to more investment or further research opportunities.
- The ability to connect with under-represented, hidden, or extreme groups makes this appealing for researchers interested in understanding niche viewpoints.
- In an online world, non-probability sampling becomes even easier to conduct, as the ability to connect with targeted sample members is faster and not constrained by physical geography.
- You and your researchers can react in real-time, meaning that analysis and research into world events can occur quicker.
- Source: <https://www.qualtrics.com/experience-management/research/non-probability-sampling/>

4.2.3 Disadvantages

- The largest disadvantage would be the presence of sampling bias as the sample selection method gives an unfair advantage to certain members of a population.
- The results from non-probability sampling are not easily scaled up and used to make generalizations about the wider population.
- In some methods, such as volunteer or convenience sampling, samples can be filled with people who are more likely to agree to want to be part of research because they hold strong views that they want to share. This can skew the validity of the results.
- As you choose deliberate selection criteria to use to assess the suitability of participants for a sample, this can result in researcher or selection bias. Your views and opinions could influence the sample, which in turn, impacts the findings of the research.
- The sample may be subject to pre-screening checks or other hurdles that make it hard for some selected participants to get into the sample itself. This further adds complicated layers that could exclude suitable candidates from ending up in the sample.
- Since there is no way to measure the boundaries of a research-relevant population, the sample size is also unclear. You may find you need more participants or less at a later stage, which could waste time and money.
- Source: <https://www.qualtrics.com/experience-management/research/non-probability-sampling/>

4.2.4 Types

- **Convenience sampling:** this form is also known as accidental, incidental, haphazard and grab opportunity. It is “where you choose participants for a sample, based on their convenience and availability. You can see this type being used in public places, like malls or school campuses, where it’s easy to meet and select people as they ‘go by’ based on the characteristics and criteria that you think are important. It is a cheap and quick way to collect people into a sample and run a survey to gather data. Because of this, it is usually used for quick user opinion polls or pilot testing.” (*What Is Non-Probability Sampling? Definition and Examples*, n.d)
- It can further be broken down into:
 - Consecutive sampling (also known as total enumerative sampling) - samples are chosen based on availability, one after the other till a conclusive result is reached;
 - Self – selection (a.k.a. volunteer sampling) – volunteers are used to fill the sample size until the required number is reached.
- **Purposive Sampling:** This is based on the intention or the purpose of study. Only those elements will be selected from the population which suits the best for the purpose of our study. **For example:** If we want to understand the thought process of the people who are interested in pursuing master’s degree then the selection criteria would be “Are you interested for Masters in..?” those who answer with ‘no’ are excluded from the sample. ³⁰ (Singh, S, 2018).

4.2.4 Types

- **Quota sampling:** aka dimension sampling. It is a non-probability sampling technique similar to stratified sampling. In this method, the population is split into segments (strata) and you have to fill a quota based on people who match the characteristics of each stratum.
- There are two types of quota sampling:
- Proportional quota sampling gives proportional numbers that represent segments in the wider population. For this, the population frame must be known.
- Non-proportional quota sampling uses stratum to divide a population, though only the minimum sample size per stratum is decided. (*What Is Non-Probability Sampling? Definition and Examples*, n.d)
- **Referral/Snowball sampling:** This technique is used in the situations where the population is completely unknown and rare. Therefore we will take the help from the first element which we select for the population and ask him to recommend other elements who will fit the description of the sample needed. So this referral technique goes on, increasing the size of population like a snowball. **For example:** It's used in situations of highly sensitive topics like HIV Aids where people will not openly discuss and participate in surveys to share information about HIV Aids. Not all the victims will respond to the questions asked so researchers can contact people they know or volunteers to get in touch with the victims and collect information. Helps in situations where we do not have the access to sufficient people with the characteristics we are seeking. It starts with finding people to study. (Singh,³¹ S, 2018)

4.3 Probability sampling

- This type of sampling is also known as random sampling, or chance sampling. Using this technique every item has an equal chance of being picked as a sample.
- There are five probability sampling designs in use by researchers:
 - Simple random sampling
 - Stratified sampling
 - Systematic sampling
 - Cluster sampling
 - Multistage sampling
 - * Due to time and space constraints, all the sampling designs are described with simple examples for each. However, the learner is encouraged to do further reading and go through examples in other literature; Kothari (2004) also provides some well explained application examples of probability sampling designs.*

4.3.1 Simple random sampling

- Every element has an equal chance of getting selected to be the part sample. It is used when we don't have any kind of prior information about the target population. (Singh, S, 2018)
- An example is when we have a population of say 20 students. Using this method every student has a probability of $1/20$ of being chosen as a sample.
- Other techniques that can be used are tossing a coin, throwing a dice, lottery method, and blindfold method. (Singh, Y, 2006).
- Advantages (Singh, Y, 2006):
 - It requires a minimum knowledge of population.
 - It is free from subjectivity and free from personal error.
 - It provides appropriate data for our purpose.
 - The observations of the sample can be used for inferential purpose.

4.3.1 Simple random sampling

- Disadvantages:
- The representativeness of a sample cannot be ensured by this method.
- This method does not use the knowledge about the population.
- The inferential accuracy of the finding depends upon the size of the sample.
- (Singh, Y, 2006)

4.3.2 Stratified sampling

- “Stratification is the process of grouping the members of the population in homogenous group before sampling. It should be ensured that each element in the population is assigned a particular stratum only. The random sampling is applied within each stratum independently. This often improves the representativeness of the sample by reducing the sampling error.” (Francis, 2010b). Prior information about the population is required in order to create the subgroups (strata).
- Stratified sampling may be of three types (Singh, Y, 2006):
 - Disproportionate stratified sampling.
 - Proportionate stratified sampling.
 - Optimum allocation stratified sampling.

4.3.2 Stratified sampling

- Advantages (Singh, Y, 2006):
 - It is ... a good representative of the population.
 - It is an improvement over the earlier (methods of random sampling).
 - It is an objective method of sampling.
 - Observations can be used for inferential purpose.
- Disadvantages (Singh, Y, 2006):
 - Serious disadvantage of this method is that it is difficult for the researcher to decide the relevant criterion for stratification.
 - Only one criterion can be used for stratification, but it generally seems more than one criterion relevant for stratification.
 - It is costly and time consuming method.
 - Selected sample may be representative with reference to the used criterion but not for the other.
 - There is a risk in generalization.

4.3.3 Cluster sampling

- Singh, S, (2018) describes cluster sampling as follows:
- Our entire population is divided into clusters or sections and then the clusters are randomly selected. All the elements of the cluster are used for sampling. Clusters are identified using details such as age, sex, location etc.
- Cluster sampling can be done in following ways:
- **Single Stage Cluster Sampling:** Entire cluster is selected randomly for sampling; this is demonstrated in fig 3.
- **Two Stage Cluster Sampling:** Here first we randomly select clusters and then from those selected clusters we randomly select elements for sampling; this is demonstrated in fig 4.
- **Systematic Clustering :** Here the selection of elements is systematic and not random except the first element. Elements of a sample are chosen at regular intervals of population. All the elements are put together in a sequence first where each element has the equal chance of being selected.

4.3.3 Cluster sampling

- For a sample of size n , we divide our population of size N into subgroups of k elements.
- We select our first element randomly from the first subgroup of k elements.
- To select other elements of sample, perform following:
- We know number of elements in each group is k i.e N/n
- So if our first element is n_1 then
- Second element is n_1+k i.e., n_2
- Third element n_2+k i.e., n_3 and so on..
- Taking an example of $N=20$, $n=5$
- No of elements in each of the subgroups is N/n i.e., $20/5 = 4 = k$
- Now, randomly select first element from the first subgroup.
- If we select $n_1 = 3$
- $n_2 = n_1+k = 3+4 = 7$
- $n_3 = n_2+k = 7+4 = 11$ (Singh, S, 2018)
- Fig 5 demonstrates this example.

4.3.3 Cluster sampling

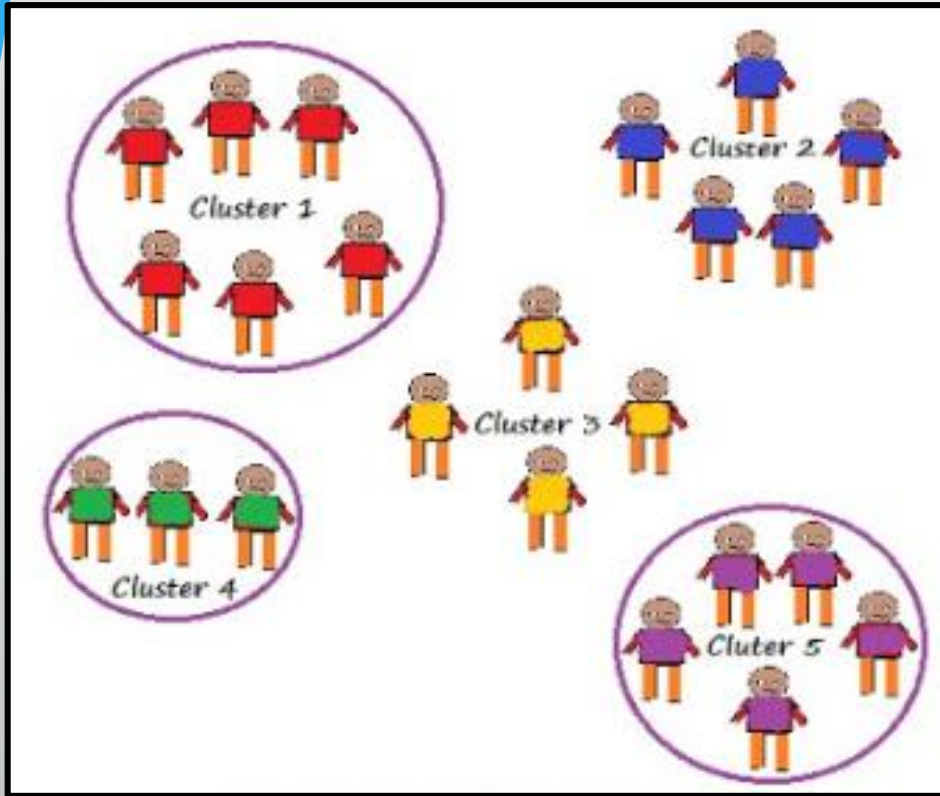


Fig 3. Single stage clustering.
(Singh, S, 2018)

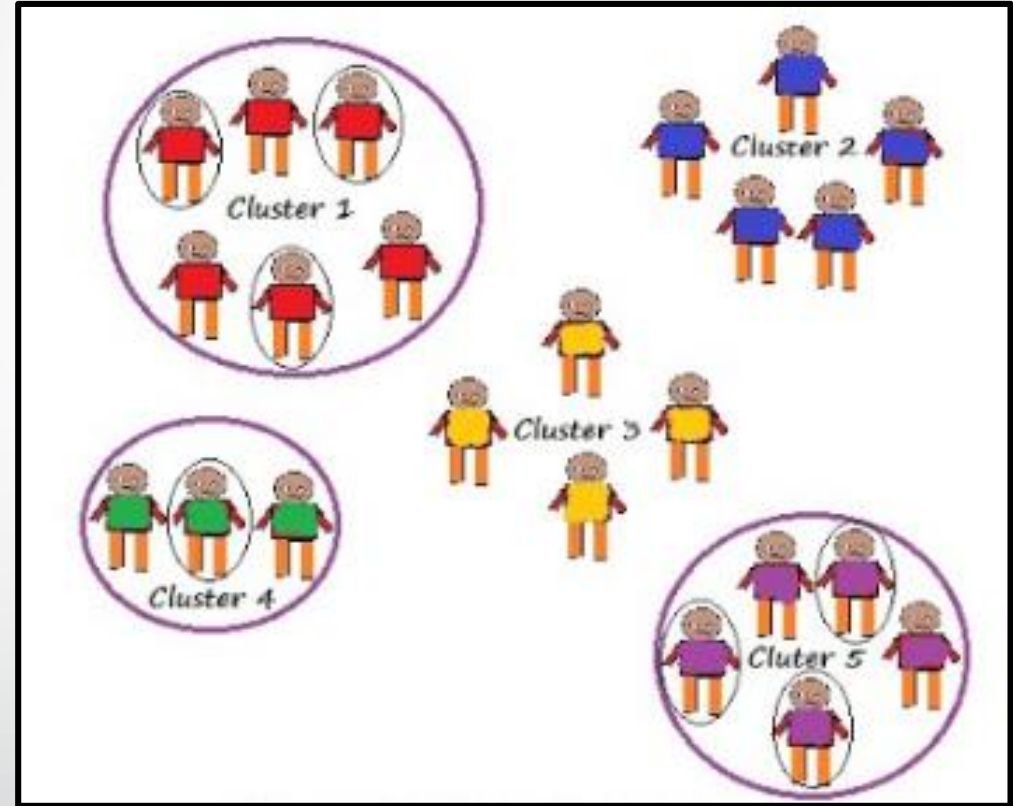


Fig 4. Two stage clustering.
(Singh, S, 2018)

4.3.3 Cluster sampling



Fig 5. Systematic clustering. (Singh, S, 2018)

4.3.3 Cluster sampling

- Advantages (Singh, Y, 2006)
 - It may be a good representative of the population.
 - It is an easy method.
 - It is an economical method.
 - It is practicable and highly applicable in education.
 - Observations can be used for inferential purpose.
- Disadvantages (Singh, Y, 2006)
 - Cluster sampling is not free from error.
 - It is not comprehensive.

4.3.4 Multistage sampling

- It is the combination of one or more methods described above.
- Population is divided into multiple clusters and then these clusters are further divided and grouped into various sub groups (strata) based on similarity. One or more clusters can be randomly selected from each stratum. This process continues until the cluster can't be divided anymore. For example country can be divided into states, cities, urban and rural and all the areas with similar characteristics can be merged together to form a strata. (Singh, S, 2018).
- Fig 6 demonstrates this concept.
- The form of probability sampling called “systematic sampling” uses the concept described in systematic clustering; therefore we shall not describe it since it uses the same principle. In fact, systematic sampling has been applied to the clustering technique in the example.

4.3.4 Multistage sampling

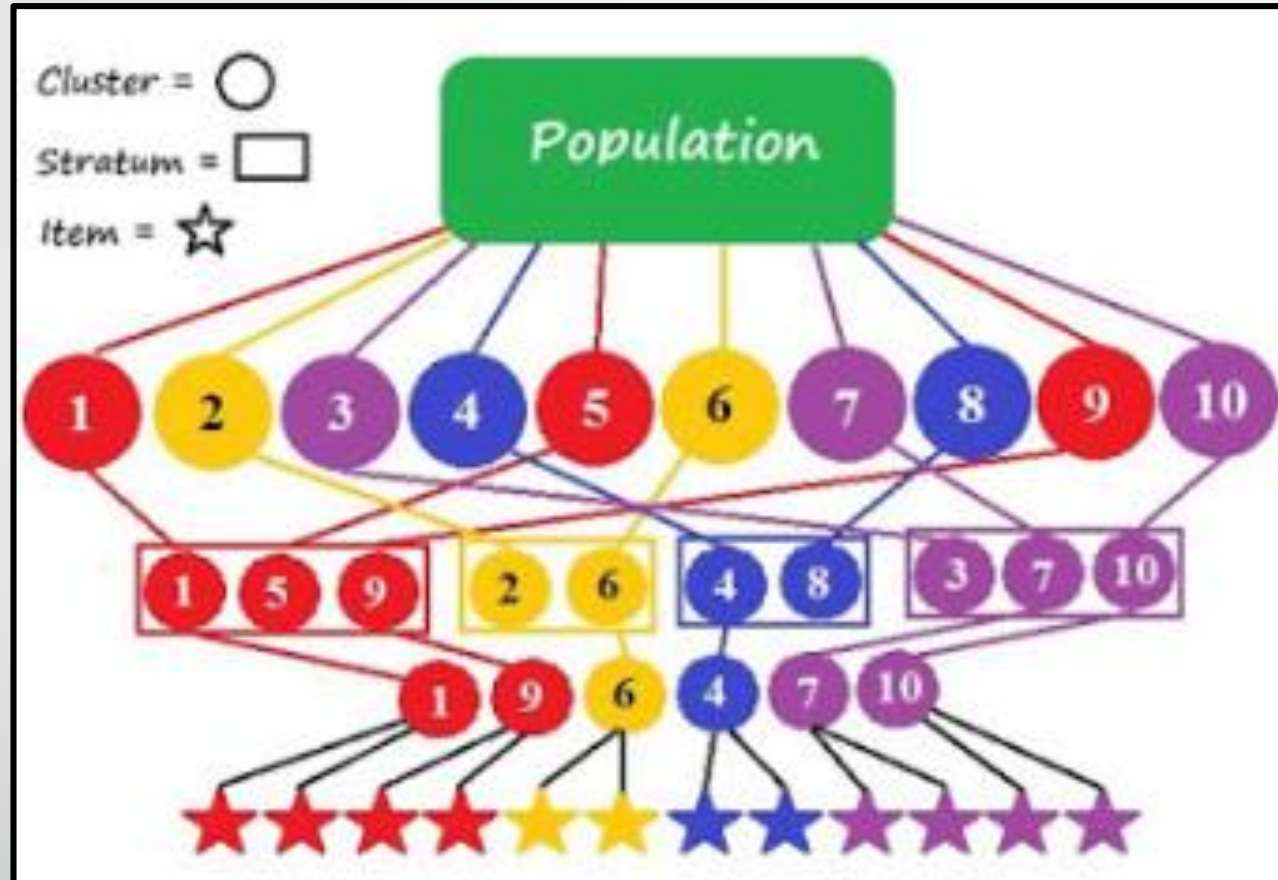


Fig 6. Multistage sampling. (Singh, S, 2018)

4.3.4 Multistage sampling

- Advantages (Singh, Y, 2006):
 - It is a good representative of the population.
 - Multi-stage sampling is an improvement over the earlier methods.
 - It is an objective procedure of sampling.
 - The observations from multi-stage sample may be used for inferential purpose.
- Disadvantages (Singh, Y, 2006):
 - It is a difficult and complex method of samplings.
 - It involves errors when we consider the primary and secondary stages.
 - It is again a subjective phenomenon.

4.3.5 Systematic sampling

- Advantages (Singh, Y, 2006):
 - This is a simple method of selecting a sample.
 - It reduces the field cost.
 - Inferential statistics may be used.
 - Sample may be comprehensive and representative of population.
 - Observations of the sample may be used for drawing conclusions and generalizations.
- Disadvantages (Singh, Y, 2006):
 - This is not free from error, since there is subjectivity due to different ways of systematic list by different individuals. Knowledge of population is essential.
 - Information of each individual is essential.
 - This method can't ensure the representativeness.
 - There is a risk in drawing conclusions from the observations of the sample.

Summary

- Advantages of sampling include saving time, saving costs and accuracy.
- A sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher would adopt in selecting items for the sample.
- The two causes of wrong interpretation are systematic bias and sampling error.
- There are different types of sample designs based on two factors viz., the representation basis and the element selection technique. On the representation basis, the sample may be probability sampling or it may be non-probability sampling. On element selection basis, the sample may be either unrestricted or restricted. When each sample element is drawn individually from the population at large, then the sample so drawn is known as 'unrestricted sample', whereas all other forms of sampling are covered under the term 'restricted sampling'.
- Non-probability sampling designs include convenience sampling, purposive sampling, quota sampling, and referral /snowball sampling
- Probability sampling designs include simple random sampling, stratified sampling, systematic sampling, cluster sampling and multi stage sampling

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