10 Inferential Statistics

Inferential statistics allows us to make predications from the data.

In class XI, you have learnt that the study of statistics can be categorized into two types: (*i*) Descriptive statistics, (*ii*) Inferential statistics.

About descriptive statistics you have learnt in class XI. In this chapter, we shall learn about inferential statistics. We shall learn about population and sample, parameter and statistic, statistical inferences and *t*-test.

POPULATION

In statistics the term population does not mean only group of people or animate creatures. In statistics, the term population also refers to group of objects, events, experiments, observations, procedures etc.

For example: All people living in India, height of all males aged above 25 years in U.P., India, blood pressure of all women aged between 40 and 60 years in Delhi, all registered voters of India, maximum temperature in June of all metro cities of India, amount of rainfall during July and August in India etc.

There are mainly two types of populations:

(*i*) Finite population

(*ii*) Infinite population

(*i*) **Finite population:** The finite population is a group of objects, events, experiments, observations etc. which are countable. It is also known as countable population.

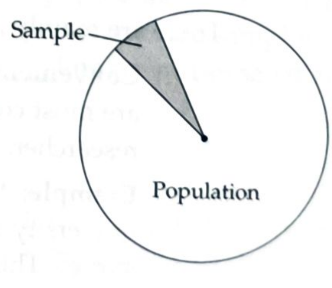
For example: All citizens of India, workers of a factory, all tax payers above 60 years in India etc.

(*ii*) **Infinite population:** The infinite population is a group of objects, events, experiments, observations etc. which are uncountable. It is also known as uncountable population.

For example: All stars in milky way, number of bacteria in persons wound etc.

SAMPLE

A sample is a smaller group of members of a population selected to represent the population.



A population contains large number of members, so it is difficult to investigate about the population by taking all the members. Therefore to study about a population, we select some members of the population called sample. A well chosen sample will contain most of the information about the population. The relation between the sample and population must be such as to allow true inferences to be made about the population from the sample.

There are mainly two types of sampling:

1. Probability sampling
2. Non-probability sampling

1. **Probability sampling:** In this type of sampling the selection of members from the population is random such that each member of the population has an equal chance of being selected. This method is also known as **random sampling**.

   There are mainly four types of probability sampling.

   (*i*) **Simple random sampling:** In a simple random sampling every member of the population has an equal chance of being selected. This is one of the most common method of sampling.

   Example: There are 1000 employees in a company A, you want to select a simple random sample of 100 employees. You assign a number to every employee in the company from 1 to 1000 and select randomly 100 numbers.

   (*ii*) **Systematic sampling:** Systematic sampling is similar to simple random sampling but is slightly easier to conduct. Every member of the population is assigned a number but instead of randomly selecting numbers, the numbers are chosen at regular intervals.

   Example: Out of 1000 employees of company A, you want to select a sample of 100 employees. All employees of the company are arranged in alphabetical order and assigned a number 1 to 1000. You randomly select a number 4 from first 10 numbers and then every 10th person in the list is selected *i.e.* 4, 14, 24, ... and end up with sample of 100 members.

   (*iii*) **Stratified sampling:** In stratified sampling the population is divided into subgroups called strata based on the relevant characteristic e.g. gender, age, income profession etc. The members from each subgroup are selected using simple random or systematic sampling.

   Example: There are 700 male employees and 300 female employees in company A, you want to select a sample of 100 employees reflecting gender balance of the company. Divide the employees into subgroups male and female employees. Select 70 male employees and 30 female employees using simple random or systematic sampling.

   (*iv*) **Cluster sampling:** Cluster sampling also divides the population into subgroups but each subgroup has similar characteristics of the whole population. This method is useful when population is dispersed.

   Example: Suppose company A has its branches in 15 cities. You want to select a sample of 100 employees. It is difficult to select members from each branch. So first select any 5 branches and then select 20 members from each selected branch.

2. **Non-probability sampling:** In this type of sampling the selection of members from the population is non-random and each member has not equal chance of being selected.

   This type of sampling is easier and cheaper to access. You can not use it to make valid statistical inferences about the population.

   There are mainly four types of non-probability sampling.

   (*i*) **Convenience sampling:** In convenience sampling the members are selected which are most convenient for researcher *i.e.* members which are easily accessible to the researcher.

   Example: Suppose you are researching about the services providing by the university to the hostel students. You may ask your fellow students to complete a survey. This is the most convenient way of gathering data.

(ii) **Voluntary response sampling:** It is similar to convenience sampling. In this sampling method people who are themselves ready to conduct the survey. Collect the sample data.

Example: Suppose you announced about the survey of hostel facilities. Some students volunteer themselves to collect the sample data.

(iii) **Judgement sampling:** This type of sampling is based on the opinion of an expert. It is also called purposive sampling. However, the quality of the sample results depends on the judgement of the person selecting the sample.

Example: You can see the selection procedure of all the reality shows. *e.g.* Indian idol in which some participates are selected by the experts among the thousands of applicants.

(iv) **Snowball sampling:** In this sampling method, we first select some persons, then with the help of selected persons we select some more and this process continues to collect the sample. It is same as a snowball increases in size as it rolls down.

Example: Suppose you are researching about the child labours of your city. You meet one child labour and he/she puts you in contact of other child labours.

REPRESENTATIVE AND NON-REPRESENTATIVE SAMPLE

Representative Sample

A representative sample is a subset of population, which accurately represents, reflects or matches the characteristic of the population. For example, if we have selected a representative sample of 10 students 6 boys and 4 girls *i.e.* boys and girls are in the ratio 3 : 2, then it follows that population also has boys and girls in the ratio 3 : 2.

For a sample to be representative sample, the selection of sample should be unbiased random and sample size must be as large to reflect most of the characteristics of the population.

Non-representative Sample

A non-representative sample is a subset of a population that does not represent, reflect the characteristics of the population. It is biased in nature.

For example, to rate a T.V. serial, a T.V. rating agency dials numbers taken at random from telephone directory is a non-representative sample because some of the viewers may not have their telephone numbers in the telephone directory.

UNBIASED AND BIASED SAMPLING

Unbiased Sampling

A sampling is called unbiased sampling if each element or member of the population has an equal chance of being chosen to be the part of the sample.

Simple random sampling, systematic sampling, stratified sampling, cluster sampling are the examples of an unbiased sampling *i.e.* we can say that probability sampling is unbiased in nature.

Biased Sampling

A sampling is called biased sampling if some elements or members of the population have higher or lower probability than others, of being chosen, to be part of the sample. Convenience sampling, voluntary sampling, judgement sampling are the examples of a biased sampling *i.e.* we can say that non-probability sampling is biased in nature.

PARAMETER AND STATISTIC

Parameter: A measurable characteristic of a population is called **parameter.** *e.g.* Population mean (μ), population variance (σ^2), population standard deviation (σ) etc.

A parameter is used to describe the entire population.

For example, we want to know the average length of a house sparrow. This is a parameter because it states the average length of whole population of house sparrows.

Statistic: A measurable characteristic of a sample is called **statistic.** For example, sample mean ($\bar{x}$), sample variance (s^2), sample standard deviation (s) etc.

In inferential statistics, we use sample statistic to estimate the corresponding population parameter. While making an inference about the population, the parameter is unknown because it is impossible to collect the information from every member of the population. So, we use sample statistic to conclude about the population parameter.

For example: We catch 100 house sparrows and measure their length. The mean length of 100 sparrows is a statistic which can be used to make an inference about the length of the entire house sparrow population.

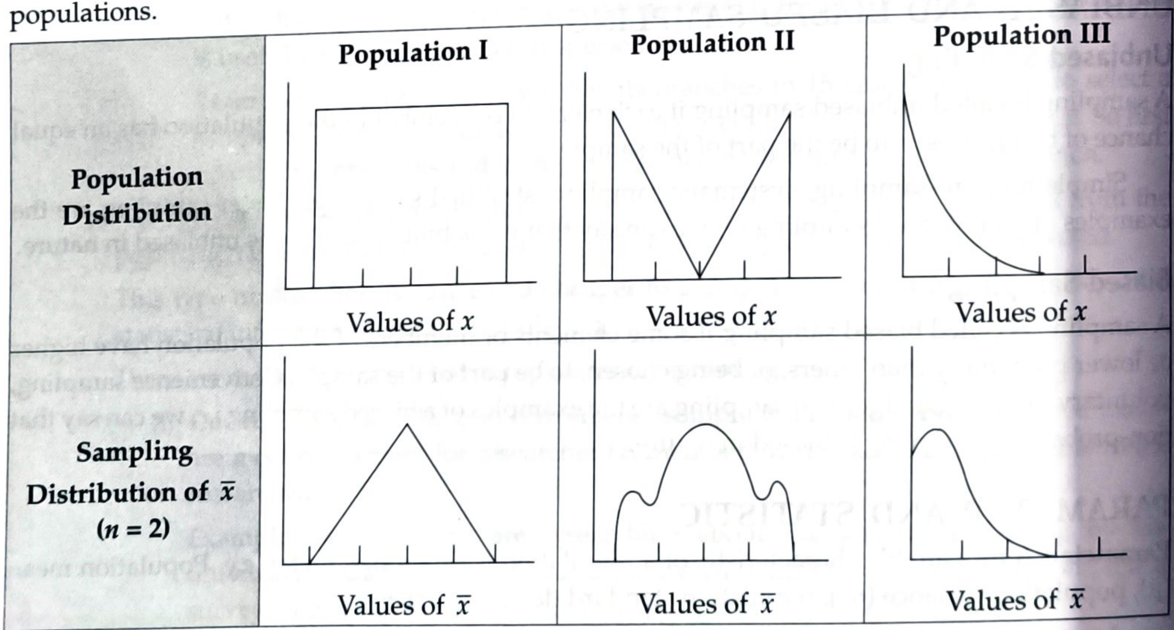
Difference between population and sample:

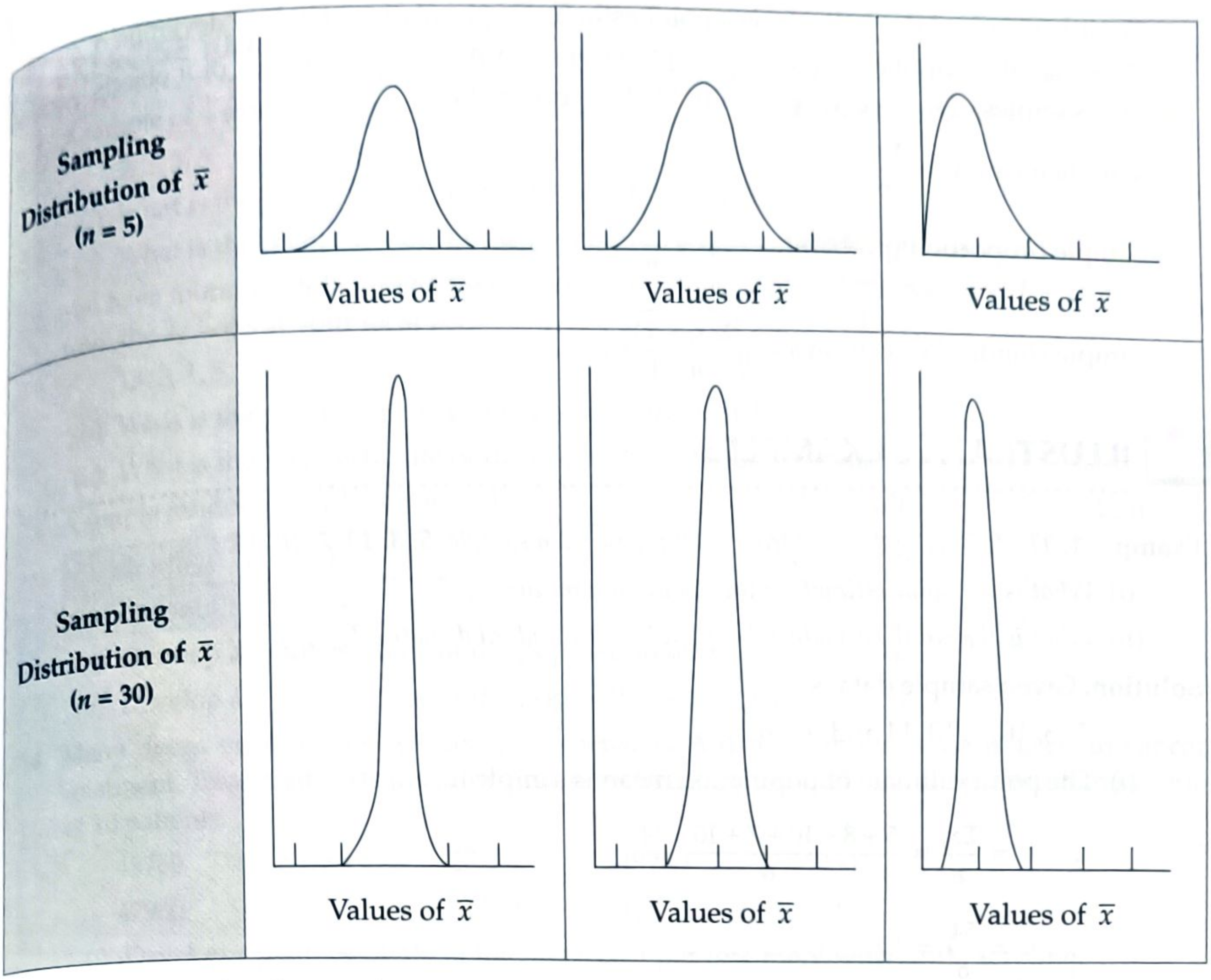
	Population	Sample
1.	Population is a collection of all elements having same characteristic *i.e.* a population includes all the elements from a set of data.	Sample is a subgroup of members of the population *i.e.* a sample consists of one or more observations drawn from the population.
2.	The measurable characteristic of population is called parameter.	The measurable characteristic of sample is called statistic.
3.	A survey done of an entire population is accurate and more precise with no margin of error.	A survey done using a sample of the population has a margin of error.
4.	The population focuses on the identification of the characteristic.	The sample makes inference about the population.

CENTRAL LIMIT THEOREM (CLT)

The Central Limit Theorem (CLT) states that the sampling distribution of the sample mean approaches a normal distribution (bell shaped curve) as the sample size gets larger, no matter what is the shape of the population distribution.

Figure given below shows how the central limit theorem works for three different populations.





In the figure each column refers to one of the populations. The topmost row of the figure shows that none of the populations are normally distributed.

The bottom three rows show the shape of the sampling distribution for samples of size $n = 2$, $n = 5$ and $n = 30$. When the sample size is 2, we see that the shape of each sampling distribution is different from the shape of the corresponding population distribution. For samples of size 5, we see that the shapes of the sampling distributions for populations I, II and III begin to look similar to the shape of a normal distribution. In population III some Skewness is to the right is still present. Finally for samples of size 30, the shape of each of the three sampling distributions are approximately normal.

A sample size of 30 or more is considered to be sufficient to hold CLT and as the sample size becomes large the prediction of characteristics of population becomes more accurate.

STATISTICAL INFERENCE

Statistical inference is a process through which inferences about the population are made based on informations obtained from the sample.

There are mainly three types of statistical inferences:

(*i*) Point Estimation (*ii*) Interval Estimation (*iii*) Hypothesis testing

POINT ESTIMATION

In statistics, **point estimation** involves the use of sample data to calculate a single value of an unknown population parameter. Single value of sample data is known as **point estimate** of corresponding population parameter.

For example, sample mean $\overline{x}$ is a point estimate of population mean μ, sample proportion $\overline{p}$ is a point estimate of population proportion p.

Sample standard deviation 's' is a point estimate of population standard deviation σ.

Suppose, the population consists of N objects and the sample consists of n objects. Also, all possible samples of n objects are equally likely to occur, then

sample mean $\bar{x} = \dfrac{\Sigma x_i}{n}$.

Sample proportion (probability) . $\bar{p} = \dfrac{x}{n}$.

Sample standard deviation $s = \sqrt{\dfrac{\Sigma(x_i - \bar{x})^2}{n-1}}$.

ILLUSTRATIVE EXAMPLES

Example 1. *The following data are from a simple random sample: 5, 8, 10, 7, 10, 14.*

(*i*) *What is the point estimate of the population mean?*

(*ii*) *What is the point estimate of the population standard deviation?*

Solution. Given sample data is

5, 8, 10, 7, 10, 14 and $n = 6$.

(*i*) The point estimate of population mean is sample mean.

$$\therefore \quad \bar{x} = \frac{\Sigma x_i}{n} = \frac{5+8+10+7+10+14}{6}$$

$$= \frac{54}{6} = 9.$$

(*ii*) The point estimate of population standard deviation is sample standard deviation.

$$\therefore \quad s = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$$

Now, $\Sigma(x_i - \bar{x})^2 = (5-9)^2 + (8-9)^2 + (10-9)^2 + (7-9)^2 + (10-9)^2 + (14-9)^2$

$= 16 + 1 + 1 + 4 + 1 + 25$

$= 48$

$$\therefore \quad s = \sqrt{\frac{48}{6-1}} = \sqrt{\frac{48}{5}} = \sqrt{9.6}$$

$$\Rightarrow \quad s = 3.1$$

Example 2. *In a survey question for a sample of 200 individuals, 80 persons gave response 'Yes', 100 gave response 'No' and 20 gave no response.*

(*i*) *What is the point estimate of the proportion in the population who respond 'Yes'?*

(*ii*) *What is the point estimate of the proportion in the population who respond 'No'?*

Solution. Given $n = 200$, $x_{\text{Yes}} = 80$, $x_{\text{No}} = 100$, $x_{\text{none}} = 20$.

(*i*) The point estimate of the proportion in the population who respond 'Yes'

$$\bar{p} = \frac{x_{\text{Yes}}}{n} = \frac{80}{200} = 0.4$$

(*ii*) The point estimate of the proportion in the population who respond 'No'

$$\bar{p} = \frac{x_{\text{No}}}{n} = \frac{100}{200} = 0.5$$

EXERCISE 10.1

1. A sample of 4 students from a school was taken to see how many pens were they carrying 2, 3, 5, 6.
   (i) What is the point estimate of the population mean?
   (ii) What is the point estimate of the population standard deviation?
2. You have found the following ages (in years) of 6 lions. These lions were randomly selected from the 22 lions at your local zoo.
   13, 2, 1, 5, 2, 7.
   (i) What is the point estimate of the population mean?
   (ii) What is the point estimate of the population standard deviation?
3. A simple random sample of 5 months of sales data provided the following information:

Months	1	2	3	4	5
Units sold	94	100	85	94	92

   (i) Develop a point estimate of the population mean of units sold.
   (ii) Develop a point estimate of the population standard deviation.
4. Many drugs used to treat cancer are expensive. A drug Anthracycline is used in cancer treatment. Treatment costs (in ₹) for Anthracycline are provided by a simple random sample of 10 patients.

43760	55780	27170	49200	44950
47980	64460	41190	42370	38140

   (i) Develop a point estimate of the mean cost per treatment with Anthracycline.
   (ii) Develop a point estimate of the standard deviation of the cost per treatment with Anthracycline.
5. A sample of 100 Maruti authorised service centres showed 13 are in Delhi, 18 in Mumbai, 17 in Chennai and 15 in Kolkata.
   (i) Develop an estimate of the proportion of Maruti Service centres in Delhi.
   (ii) Develop an estimate of the proportion of Maruti Service centres in Chennai.
   (iii) Develop an estimate of the proportion of Maruti Service centres that are not in these four cities.

Answers

1. (i) 4 (ii) 1.83 2. (i) 5 (ii) 4.52 3. (i) 93 (ii) 5.39
4. (i) ₹45500 (ii) ₹10038.05 5. (i) 0.13 (ii) 0.17 (iii) 0.37

INTERVAL ESTIMATION

In interval estimation we find two numbers using sample statistic between which a population parameter lie. For example, $a < \mu < b$ is an interval estimate of the population mean μ. It indicates that population mean is greater than a but less than b.

To learn about interval estimation we need the knowledge of the following concepts:

Confidence Interval

A confidence interval is a range of values, derived from sample statistic which is likely to contain the value of an unknown population parameter.

A confidence interval consists of three parts:

1. Confidence level
2. Sample statistic
3. Margin of error

1. **Confidence level:** The confidence level describes the uncertainty of a sampling method *i.e.* the probability part of a confidence interval is called **confidence level**. Confidence level written in decimal is called **confidence coefficient**.

   For example: Suppose we collect some samples from a given population and compute confidence interval for each sample. A 95% confidence level means that 95% of the interval contain the true population parameter. Here confidence level is 95% and confidence coefficient is 0.95.

2. **Sample statistic:** It is sample statistic for which the estimation of population parameter is done.

3. **Margin of error:** In a confidence interval, the range of values, above and below the sample statistic is called margin of error.

   For example: Suppose a news channel conducted an exit poll and reports that candidate X will receive 40% of the vote. The channel claimed that exit poll had a 5% margin of error and confidence level is 90%. It means channel is 90% confident that candidate X will get between 35% and 45% of the vote.

Interval Estimation of Population Mean

In order to develop an interval estimate of a population mean, the population standard deviation σ or sample standard deviation 's' must be known to compute the margin of error. In most of the cases σ is not known. We shall learn to estimate the margin of error when σ is not known in the later part of this chapter. Here we shall discuss to estimate the margin of error when σ is known.

The interval estimation of population mean is given by the formula:

$$\mu = \bar{x} \pm \text{margin of error}$$

where $\bar{x}$ = sample mean and μ = population mean.

Calculation of Margin of Error (σ known)

The formula of calculating the margin of error is

$$\text{Margin of error} = Z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}}$$

where $(1 - \alpha)$ is called confidence coefficient and $Z_{\alpha/2}$ is the Z value providing an area of $\frac{\alpha}{2}$ in the upper tail of the standard normal probability distribution.

The values of $Z_{\alpha/2}$ for most commonly used confidence levels is given below:

Confidence level	α	$\frac{\alpha}{2}$	$Z_{\alpha/2}$
90%	0.10	0.05	1.645
95%	0.05	0.025	1.960
99%	0.01	0.005	2.576

ILLUSTRATIVE EXAMPLES

Example 1. *A simple random sample of 50 items from a population with $\sigma = 6$ resulted in a sample mean of 32. Provide a 95% confidence interval for the population mean.*

Solution. Given, $n = 50, \sigma = 6, \bar{x} = 32$

Confidence level = 95%

$$\Rightarrow \quad 1 - \alpha = 0.95 \Rightarrow \alpha = 0.05 \Rightarrow \frac{\alpha}{2} = 0.025$$

$$\therefore \quad Z_{\alpha/2} = Z_{0.025} = 1.96 \qquad \text{(Using table)}$$

$$\text{Now, margin of error} = Z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}}$$

$$= 1.96 \times \frac{6}{\sqrt{50}}$$

$$= 1.96 \times 0.848 = 1.66$$

$$\because \quad \mu = \bar{x} \pm \text{margin of error}$$

$$= 32 \pm 1.66$$

So, confidence interval is (32 – 1.66, 32 + 1.66) *i.e.* (30.34, 33.66).

Example 2. *Suppose a student measuring the boiling temperature of a certain liquid observes the reading (in degree Celsius) 102.5, 101.7, 103.1, 100.9, 100.5 and 102.2 on 6 different samples of the liquid. If he knows that the standard deviation for this procedure is 1.2°C, what is the interval estimation for the population mean at a 95% confidence level?*

Solution. Given, $n = 6, \sigma = 1.2$, confidence level = 95%

and observations are 102.5, 101.7, 103.1, 100.9, 100.5, 102.2

$$\text{Sample mean } \bar{x} = \frac{102.5 + 101.7 + 103.1 + 100.9 + 100.5 + 102.2}{6}$$

$$= \frac{610.9}{6} = 101.816 = 101.82$$

Confidence level = 95%

$$\Rightarrow \quad (1 - \alpha) = 0.95 \Rightarrow \alpha = 0.05 \Rightarrow \frac{\alpha}{2} = 0.025$$

$$\therefore \quad Z_{\alpha/2} = Z_{0.025} = 1.96 \qquad \text{(Using table)}$$

$$\text{Margin of error} = Z_{0.025} \cdot \frac{1.2}{\sqrt{6}} = 1.96 \times 0.49 = 0.96$$

$$\because \quad \mu = \bar{x} \pm \text{margin of error}$$

$$= 101.82 \pm 0.96$$

So, confidence interval is

(101.82 – 0.96, 101.82 + 0.96) *i.e.* (100.86, 102.78).

Example 3. *A 95% confidence interval for a population mean was reported to be 152 to 160. If $\sigma = 15$, what sample size was used in this study?*

Solution. Given $\sigma = 15$, confidence level = 95%, confidence interval (152, 160).

Let the sample mean be $\bar{x}$ and margin of error be E,

then $\bar{x} - E = 152$ ...(*i*)

and $\bar{x} + E = 160$ ...(*ii*)

Subtracting equation (*i*) from (*ii*), we get

$$2E = 8 \Rightarrow E = 4$$

Also, $1 - \alpha = 0.95 \Rightarrow \alpha = 0.05 \Rightarrow \frac{\alpha}{2} = 0.025$

$$\Rightarrow \quad Z_{\alpha/2} = Z_{0.025} \Rightarrow Z_{\alpha/2} = 1.96$$

We know that margin of error $= Z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}}$

$$\Rightarrow \quad 4 = 1.96 \times \frac{15}{\sqrt{n}}$$

$$\Rightarrow \quad \sqrt{n} = \frac{1.96 \times 15}{4}$$

$$\Rightarrow \quad \sqrt{n} = 0.49 \times 15$$

$$\Rightarrow \quad \sqrt{n} = 7.35 \Rightarrow n = (7.35)^2$$

$$\Rightarrow \quad n = 54.0225 \Rightarrow n = 54$$

So, sample size is 54.

Example 4. *Suppose that a 95% confidence interval states that population mean is greater than 100 and less than 300. How would you interpret this statement?*

Solution. Given confidence level = 95% , confidence interval (100, 300).

Let the sample mean be $\bar{x}$ and margin of error be E, then

$$\bar{x} - E = 100 \text{ and } \bar{x} + E = 300.$$

Solving these two equations, we get

$$\bar{x} = 200 \text{ and } E = 100.$$

Hence, sample mean is 200 and margin of error is ± 100.

INTERVAL ESTIMATION OF POPULATION PROPORTION

The interval estimation of population proportion is given by the following formula:

$p = \bar{p} \pm$ margin of error

where $\bar{p}$ = sample proportion and p = population proportion.

The formula of calculating the margin of error is:

$$\text{Margin of error} = Z_{\alpha/2}\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}.$$

Example 5. *A simple random sample of 400 individuals provides 100 Yes responses.*

(*i*) *What is the point estimate of the population proportion that would provide Yes responses?*

(*ii*) *Compute the 95% confidence interval for the population proportion.*

Solution. Given, $n = 400$ and $x_{\text{Yes}} = 100$

(*i*) The point estimate of the proportion in population who respond Yes

$$\bar{p} = \frac{x_{\text{Yes}}}{n} = \frac{100}{400} = 0.25$$

(*ii*) Given, $1 - \alpha = 0.95 \Rightarrow \frac{\alpha}{2} = 0.025$

So, $Z_{\alpha/2} = Z_{0.025} = 1.96$

Now, margin of error = $Z_{\alpha/2}\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$

$$= 1.96\sqrt{\frac{0.25(1-0.25)}{400}} = 1.96\sqrt{\frac{0.25 \times 0.75}{400}}$$

$$= \frac{1.96 \times 0.25}{20} \times \sqrt{3} = 0.0424$$

$\because\ p = \overline{p} \pm$ margin of error

$= 0.25 \pm 0.0424$

So, confidence interval is

(0.25 – 0.0424, 0.25 + 0.0424) *i.e.* (0.2076, 0.2924).

EXERCISE 10.2

1. A simple random sample of 50 items from a population with $\sigma = 6$ resulted in a sample mean of 32.
   (*i*) Provide a 90% confidence interval for the population mean.
   (*ii*) Provide a 99% confidence interval for the population mean.
2. A simple random sample of 60 items resulted in a sample mean of 80. The population standard deviation is $\sigma = 15$.
   (*i*) Compute the 95% confidence interval for the population mean.
   (*ii*) Assume that same sample mean was obtained from a sample of 120 items. Provide a 95% confidence interval for the population mean.
3. A survey for prices of a particular product in different stores of a city is conducted. The prices of the product in 16 different stores are given below:
   ₹100, ₹108, ₹97, ₹99, ₹112, ₹99, ₹98, ₹104, ₹107, ₹95, ₹110, ₹103, ₹110, ₹111, ₹106, ₹105.
   Assuming that prices of this product follow a normal law of variance of 25.
   (*i*) Compute the sample mean of the distribution.
   (*ii*) Determine the 95% confidence interval for the population mean.
4. The average height of a random sample of 400 adult males of a city is 175 cm. It is known that population standard deviation is 40.
   (*i*) Determine the 90% confidence interval for the population mean.
   (*ii*) Determine the 95% confidence interval for the population mean.
5. The monthly sales of a plywood shop are normally distributed with a standard deviation of ₹ 900. A statistical study of sales in the last nine months has found a confidence interval for the mean of monthly sales with extremes of ₹ 4663 and ₹ 5839.
   (*i*) What were the average sales over the nine month period?
   (*ii*) What is the confidence level for this interval?
6. A 99% confidence interval for a population mean was reported to be 83 to 87. If $\sigma = 8$, what sample size was used in this study?
7. A simple random sample of 800 elements generates a sample proportion $\overline{p} = 0.70$
   (*i*) Provide a 90% confidence interval for the population proportion.
   (*ii*) Provide a 95% confidence interval for the population proportion.
8. In a survey, the sample proportion for the population proportion is $\overline{p} = 0.35$. How large a sample should be taken to provide a 95% confidence level with a margin of error of 0.05?

9. A survey of 611 office workers investigated telephone answering practices, including how often each office worker was able to answer incoming telephone calls and how often incoming telephone calls went directly to voice mail. A total of 281 office workers indicates that they never need voice mail and are able to take every telephone call.

(i) What is the point estimate of the population proportion of office workers who are able to take every telephone call?

(ii) At 90% confidence level, what is the margin of error?

(iii) What is the 90% confidence interval for the proportion of population of office workers who are able to take every telephone call?

10. According to a financial report, the majority of companies reporting profits had beaten estimates. A sample of 162 companies showed 104 beat estimates, 29 matched estimates and 29 fell short.

(i) What is the point estimate of the proportion that fell short of estimates?

(ii) Determine the margin of error and provide a 95% confidence interval for the proportion that beates estimates.

(iii) How large a sample is needed if the desired margin of error is 0.05?

Answers

1. (i) (30.6, 33.4) (ii) (29.81, 34.19)
2. (i) (76.2, 83.8) (ii) (77.32, 82.68)
3. (i) 104 (ii) (101.55, 106.45)
4. (i) (171.71, 178.29) (ii) (171.08, 178.92)
5. (i) ₹ 5251 (ii) 95%
6. 106
7. (i) (0.6733, 0.7267) (ii) (0.6682, 0.7318)
8. 350
9. (i) 0.4599 (ii) 0.0332 (iii) (0.4267, 0.4931)
10. (i) 0.1790 (ii) 0.0738; (0.5682, 0.7158) (iii) 353