Standard Error: The Standard Deviation of a sampling distribution is known as Standard Error.

Standard Error of sample mean ($\bar{x}$)

Case 1: Population N is very large and sample size n is small, (less than 5% of the population).

$$\mathrm{S.E}(\bar{x}) = \sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

Case 2: Population N is finite, sampling without replacement or sample size is large

i.e., (5% or greater than 5% of the population).

$$\mathrm{S.E}(\bar{x}) = \sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \times \sqrt{\frac{N-n}{N-1}}$$

Note: the factor

$$\frac{N-n}{N-1}$$

Known as **Finite Population Correction (FPC)** and uses for adjusting the variability in large samples.

Standard Error of sample proportion (p)

Case 1: Population N is very large and sample size n is small, (less than 5% of the population).

$$\mathrm{S.E}(p) = \sigma_p = \sqrt{\frac{p(1-p)}{n}}$$

Case 2: Population N is finite, sampling without replacement or sample size is large

i.e., (5% or greater than 5% of the population).

$$\mathrm{S.E}(p) = \sigma_p = \sqrt{\frac{p(1-p)}{n}} \times \sqrt{\frac{N-n}{N-1}}$$

Confidence Intervals

$$\bar{x} - \sigma_{\bar{x}} \times z_{1-\frac{\alpha}{2}} < \mu < \bar{x} + \sigma_{\bar{x}} \times z_{1-\frac{\alpha}{2}} \qquad (\sigma \text{ known})$$

$$p - \sigma_p \times z_{1-\frac{\alpha}{2}} < \pi < p + \sigma_p \times z_{1-\frac{\alpha}{2}} \qquad (\text{Proportion})$$

$$\bar{x} - \frac{\hat{S}}{\sqrt{n}} \times z_{1-\frac{\alpha}{2}} < \mu < \bar{x} + \frac{\hat{S}}{\sqrt{n}} \times z_{1-\frac{\alpha}{2}} \qquad (\sigma \text{ unknown})$$

$$\bar{x} - \frac{\hat{s}}{\sqrt{n}} \times t_{v,\left(1-\frac{\alpha}{2}\right)} < \mu < \bar{x} + \frac{\hat{s}}{\sqrt{n}} \times t_{v,\left(1-\frac{\alpha}{2}\right)} \qquad (v = d.f = n-1)$$

Z – Distribution (Standard Normal Distribution) and student's – t distribution

Sample Size (n)	**Population Standard Deviation (σ)**	**Sample statistic $\bar{x}$**	**Sampling Distribution**
$n \geq 30$	Known	Known	Z
$n < 30$	Known	Known	Z
$n \geq 30$	Unknown	Known	Z
$n < 30$	Unknown	Known	T

1. Sometimes, $\bar{x}$ unknown but data set is provided, then we calculate $\bar{x}$ by using the formula.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

2. When σ unknown and $n \geq 30$, either $\hat{S}$ is provided already or we have to calculate $\hat{S}$ by the following formulas.

$$\hat{S} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \left(\frac{1}{n}\sum_{i=1}^{n} x_i\right)^2}$$

OR

$$\hat{S} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

3. When σ unknown and $n < 30$, then, either $\hat{s}$ is provided already or we have to calculate $\hat{s}$ by the following formulas.

$$\hat{s} = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right]}$$

OR

$$\hat{s} = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n}(x_i - \bar{x})^2\right]}$$