ANALYSIS OF VARIANCE (ANOVA)

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- The analysis of variance(ANOVA) is developed by R.A.Fisher in 1920.

- The technique of variance analysis developed by fisher is very useful in such cases and with its help it is possible to study the significance of the difference of mean values of a large no.of samples at the same time.

CLASSIFICATION OF ANOVA

- The Analysis of variance is classified into two ways:
- One-way classification
- Two-way classification

In a one-way classification we take into account the effect of only one variable.

If there is a two way classification the effect of two variables can be studied.

One Way ANOVA

Steps

1. State null & alternative hypothesis
2. State Alpha
3. Calculate degrees of Freedom
4. State decision rule
5. Calculate test statistic
6. Calculate F statistic

8	7	12
10	5	9
7	10	13
14	9	12
11	9	14

1)Null hypothesis

- No significant difference in the means of 3 samples

2)State Alpha i.e 0.05

3)Calculate degrees of Freedom

k-1 & n-k= 2 & 12

4)State decision rule

- Table value of F at 5% level of significance for d.f 2 & 12 is

3.88

- The calculated value of F > 3.88 ,H0 will be rejected

5) Calculate test statistic

Source of Variation	SS (Sum of Squares)	Degrees of Freedom	MS (Mean Square)	Variance Ratio of F
Between Samples	SSC	k-1	MSC= SSC/(k-1)	MSC/MSE
Within Samples	SSE	n-k	MSE= SSE/(n-k)	
Total	SS(Total)	n-1		

X1	X2	X3
8	7	12
10	5	9
7	10	13
14	9	12
11	9	14
Total 50 M1= 10	40 M2 =8	60 M3 =12

$$\text{Grand average} = \frac{10 + 8 + 12}{3} = 10$$

Sum of squares between samples (SSC)

Sum of squares between samples (SSC) =

n1 (**M1** – Grand avg)^2 + n2 (**M2** – Grand avg)^2 + n3(**M3** – Grand avg)^2

5 (10 - 10)^2 + 5 (8 - 10)^2 + 5 (12 - 10)^2 = 40

$$MSC = \frac{SSC}{k-1} = \frac{40}{2} = 20$$

Sum of squares WITH IN samples

X1	$(X1 - M1)^2$	X2	$(X2- M2)^2$	X3	$(X3- M3)^2$
8	4	7	1	12	0
10	0	5	9	9	9
7	9	10	4	13	1
14	16	9	1	12	0
11	1	9	1	14	4
	30		16		14

Sum of squares within samples (SSE) = 30 + 16 +14 =60

$$MSE = \frac{SSE}{n-k} = \frac{60}{12} = 5$$

Calculation of ratio F

$$\text{F-statistic} = \frac{MSC}{MSE} = 20/5 = 4$$

The Table value of F at 5% level of significance for d.f 2 & 12 is 3.88
The calculated value of F > table value
H0 is rejected. Hence there is significant difference in sample means

Two way ANOVA

Include tests of three null hypotheses:

1) Means of observations grouped by one factor are same;

2) Means of observations grouped by the other factor are the same; and

3) There is no interaction between the two factors. The interaction test tells whether the effects of one factor depend on the other factor

Two Way ANOVA

Example

- we have test score of boys & girls in age group of 10 yr,11yr & 12 yr. If we want to study the effect of gender & age on score.

- Two independent factors- Gender, Age Dependent factor - Test score

Source of variance	d.f	Sum of squares	Mean sum of squares	F-Ratio
Between samples(columns)	d f 1 =C-1	SSC=B-D	MSC=SSC/ d f	F=MSC/ MSE
Between Replicants(rows)	d f 2 =r-1	SSR=C-D	MSR=SSR/ d f 2	
Within samples(Residual)	d f 3=(c-1)(r-1)	SSE=SST-(SSC+SSR)	MSE=SSE/ d f 3	F=MSR/ MSE
Total	n-1	SST=A-D		

APPLICATIONS OF ANOVA

- Similar to t-test
- More versatile than t-test
- ANOVA is the synthesis of several ideas & it is used for multiple purposes.
- The statistical Analysis depends on the design and discussion of ANOVA therefore includes common statistical designs used in pharmaceutical research

- In the bioequivalence studies the similarities between the samples will be analyzed with ANOVA only.

- Pharmacokinetic data also will be evaluated using ANOVA.

- Pharmacodynamics (what drugs does to the body) data also will be analyzed with ANOVA only.