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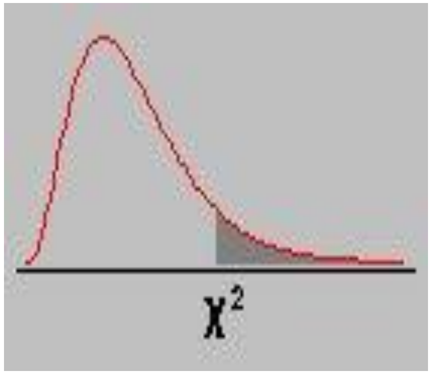


LVII

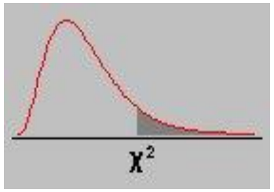
Chi Square (x^2) test

Part 1

Prof. Dr. Waqar AL-Kubaisy

@ August 5- 2025

SPECIFIC LEARNING OUTCOMES



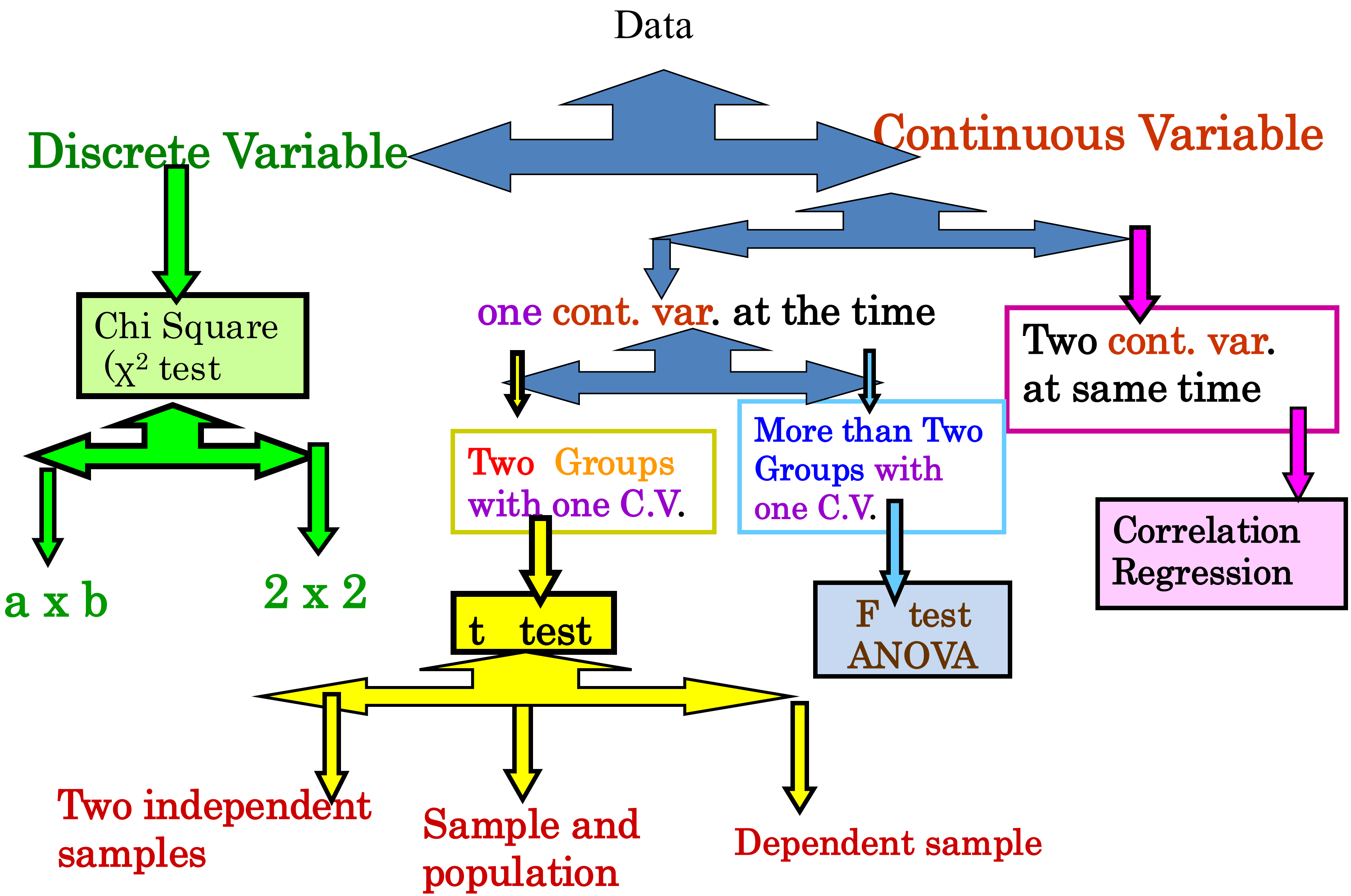
On completion of this lecture, you should be able to:

1. Explain the basis for the use of Chi square tests
2. Explain the **limitations of the Chi square** tests
3. **Carry out the** Chi square tests
4. **Interpret the findings** from the Chi square tests of significance
5. Interpret degrees **of freedom and critical** values of Chi square statistics from **Chi square table**

CONTENTS

1. **Explanation of the basis for** the use of Chi square tests on qualitative data
1. Explanation of the limitations of the Chi square tests
2. Calculation of Chi square
3. Chi square table
4. Interpretation of the findings from the Chi square tests of significance

An important thing is the type of the variable concerned.



An important thing is the type of the variable concerned.

when the data measurement is continuous

t test be applied

to test significance difference between two means

Body weight,

♀ $\overline{x}$ ♂ $\overline{x}$ ♂ Jordan,   ♂ Iraq

ANOVA (F test) be applied

to test significance difference among more than two means Body weight adult males

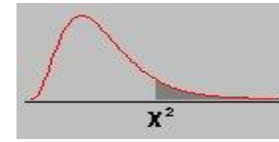
$\overline{x}$ Egypt $\overline{x}$ Palestine $\overline{x}$ Jordan, $\overline{x}$ Iraq

Numbers of students who were succeeded

succeeded

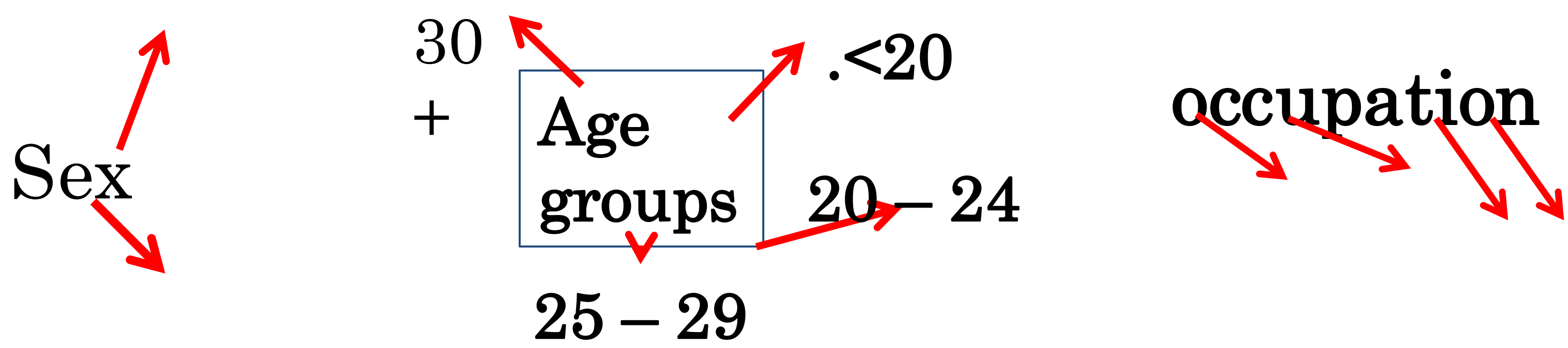
♂ 70   ♀ 90

An important thing is the type of the variable concerned.



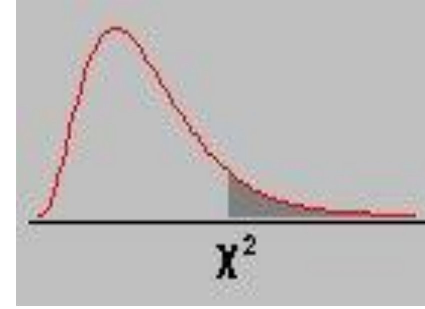
The data we have here is only enumerative data or **counting data .**

Counting No. of individuals falling in one category, class, group or another



The data consist of counting No. in each sample or group

An important thing is the type of the variable concerned.



Mutah
170

Baghdad
180

100
♀

75
♂

Numbers of students who were succeeded

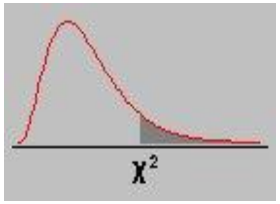
??????

????????

??

cause could be

??



	succeeded
Baghdad	180
Mutah	170

????? cause could be

	succeeded
Baghdad	180
UiTM	220
Syria	200
Mutah	170

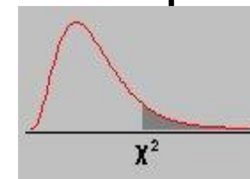
?????

Numbers of students who were succeeded

cause could be

Therefore

	Total	succeeded	%	Not succeeded
Baghdad	240	180	75%	60
Mutah	200	170	85%	30
	440	350		90



Proportion succeeded
350/440=0.80

Proportion succeeded at Mutah ??

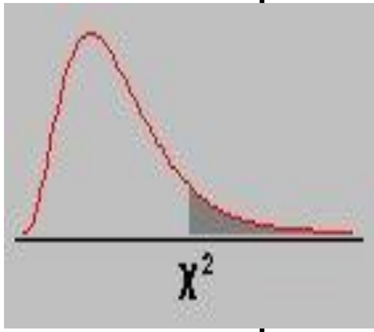
0.8X200=160

Proportion succeeded at Baghdad ??

0.8X240=192

cause could be

	Total	succeeded	%	Not succeeded
Baghdad	220	180	82%	40
Mutah	200	170	85%	30
Syria	320	200	62.5%	120
UiTM	380	220	57.9%	160
	1120	770		350



770/1120 = 0.687

350/1120 = 0.3125

770/1120 X 100 = 68.7%

350/1120 X100 = 31.25%

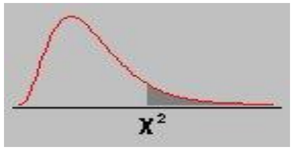
Proportion succeeded at Mutah ??

Proportion succeeded at Baghdad ??

Proportion succeeded at Syria ??

Proportion succeeded at UiTM ??

When data measurement is



counting data
Categorical data
Discrete.

The data consist of proportion of individuals in each group or sample

- We have absolute numbers
- We have counting numbers so

- comparing between
- Rates , proportions of individuals in each group
  - Two groups
  - More than two groups

statistical inference are made in term of difference in proportions

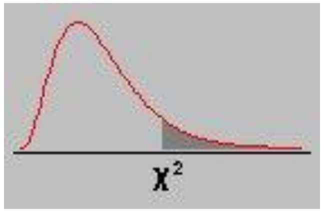
$$Ho = P_1 = P_2 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_0$$

We classify persons into categories such as

- male female
- Smoker not smoker
- Succeeded and not succeeded…etc
- smoker, not smoker and X smoker
- then

	male	female	total
Present			
Absent			
total			



➢count the number of observation fall in each category

The result is frequency data

enumerative data because we enumerate the No. of person in each category

Categorical data , because we count the No. of person in each category

An important thing is the type of the variable concerned.

When measurement

Comparing the difference When measurement is merely the presence or absence of certain condition,

Absolute No X

✓ Proportion √

The Population Parameter is

P: the proportion of condition in population

which is estimated by

P: the proportion of condition in the sample

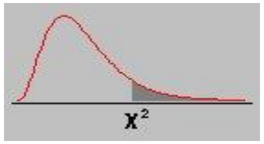
So

Testing hypothesis about population proportion "P"

based on sample proportion P

is similar to testing hypothesis about μ .

An important thing is the type of the variable concerned.



The techniques for testing hypothesis concerning

counting data
Categorical data
Discrete

is known as chi square (χ^2) test .

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Chi square is

used in testing difference in proportions

$$Ho = P_1 = P_2 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_0$$

while t test and F test are used in testing difference in means .

An important thing is the type of the variable concerned.

Also classification could be **more than 2 groups**, could be three, four, five ………. K groups .

P1 P2 P3 P4 P5 ……….. Pk

Tumour stage I II III ……..

Class stage level I II III IV V

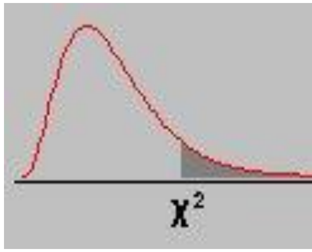
P1 P2 P3 P4 P5 ……….. Pk

In this case

$$Ho = P_1 = P_2 = P_3 = P_4 = P_5 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_3 \neq P_4 \neq P_5 \neq P_0$$

	Jordanian	Iraqi	Syrian	Egyptian	total
smoker					
Not smoker					
total					



When measurement is

merely the presence or absence of certain condition,

Absolute No X

✓ Proportion

the population parameter is

P: :the proportion of condition in population

which is estimated by

P: the proportion of condition in the sample

So

	Total	succeeded	%	Not succeeded
Baghdad	240	180	75%	60
Mutah	200	170	85%	30
	440	350		90

Proportion succeeded
350/440=0.80

Testing hypothesis about population proportion "P"

based on sample proportion P

If the true population proportion of condition is Po

and sample size is N, So

Po N = Total No. of condition that expected (E)

in population .

$$\chi^2 = \sum \frac{(O-E}{E}$$

Proportion succeeded
at Mutah = 0.8X200=160

Proportion succeeded
at Baghdad=0.8X240=192

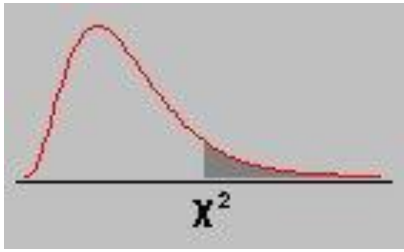
192 =160 ????

Chi square test denoted X^2

This has two common applications:

first as test

whether two categorical variables are independent or not;



$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

second as a test of

whether two proportions are equal or not

$$Ho = P_1 = P_2 = P_0$$

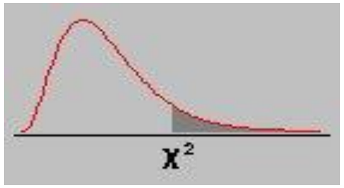
$$H_A = P_1 \neq P_2 \neq P_0$$

$$Ho = P_1 = P_2 = P_3 = P_4 = P_5 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_3 \neq P_4 \neq P_5 \neq P_0$$

contingency table

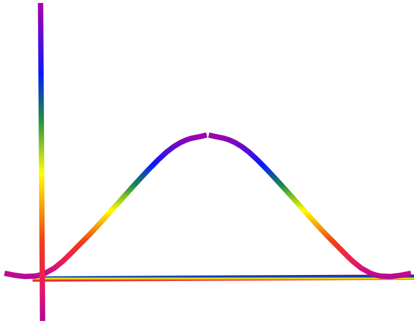
- The chi square test is applied to frequency data in form of a contingency table



i.e. a table of cross- tabulations) with

- the rows represent categories of one variable and
- the columns categories of a second variable.

	♂	♀	total
succeeded	70(87.5%)	90 (75%)	160
not succeeded	10 ( )	30 ( )	40
Total	80	120	200



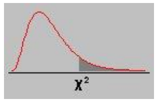
- The null hypothesis
  a)is that the two variables are unrelated
  b) ?????????

the rows represent categories of one variable and the columns categories of a second variable

Sex	succeeded	not succeeded	Total
♂	70 (87.5%)	10	80
♀	90 (75%)	30	120
Total	160	40	200

The H0; is that the two variables are unrelated

The HA ???????????????



If the variables display are Exposure and outcome.

Then

usually we arrange the table with

Exposure as the row variable and

Out come as the column variable .

and display % corresponding the exposure variable

Exposure	Out come +ve	Out come -ve	total
yes			
no			
Total			

Example

smoking during pregnancy and relation to small birth weight

smoker or non smoked mother during pregnancy??

small birth weight no small birth weight ???

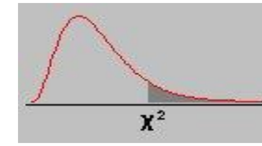
	Small birth weight	no small birth weight	Total
smoker mother during pregnancy			
non smoked mother during pregnancy			
Total			

merely the presence or absence of certain condition,

Absolute No X

✓ Proportion

An important thing is the type of the variable concerned.



	♂	♀	total
succeeded	70 87.5%	90 75%	160 80%
not succeeded	10 12.5%	30 25%	40
Total	80	120	200

If the true population proportion of condition is

160/200 =0.8 40/200 = 0.2

Po =0.8 and

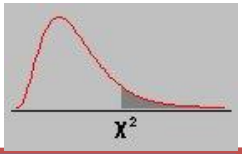
Rate (proportion) of succeeded ♂ (p_1)=70/80= 87.5%

Rate(proportion) of succeeded ♀ (p_2)= =90/120= 75%

$$Ho = P_1 = P_2 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_0$$

????



	♂	♀	total
succeeded	70 (87.5%)	90 (75%)	160 80%
not succeeded	10 (12.5%)	30 (25%)	40
Total	80	120	200

If the true population proportion of condition is

160/200 =0.8 40/200 = 0.2

Po =0.8 and

sample size is N, (200) So

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Po N =Total No. of condition that expected (E)

in Each population .

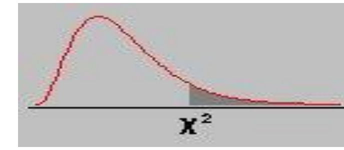
♂ 80X 0.8= 64 80X 0.2 =

♀ 120X 0.8= 96 120X 0.2=

sign. Difference in proportion

expected (E)

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$



♂	80X.8=	80X.2 =
♀	120X.8=	120X.2=

Out come	♂ O	♂ E	♀ O	♀ E	total
succeeded	70	64	90	96	160
not succeeded	10	16	30	24	40
Total	80		120		200

$$\sum O - E = Zero$$

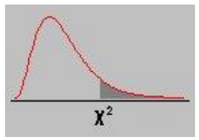
$$\sum \frac{O-E}{E} = Zero$$

- the actual **observed** No. of subject with condition **(O)**
- and the **expected** No. of condition **(E)**
- **Looking for the difference between the**
- **observed and expected frequencies**

$$\sum O - E = Zero \qquad \sum \frac{O-E}{E} = Zero$$

So if the actual No. of subject with condition observed No.(O) is close to the expected No. (E) then the Ho will be not rejected (   ).

This mean that P=Po .



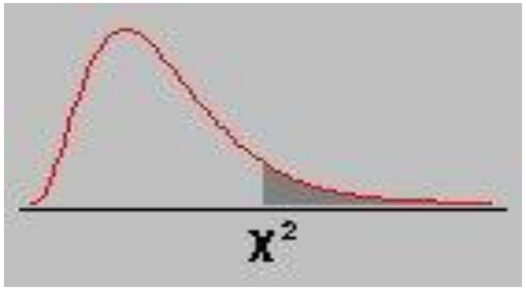
Usually summation $\sum O - E = Zero$ $\sum \frac{O - E}{E} = Zero$ So

To overcome this result, we have to square O-E make it as $(O-E)^2$ then divided by E for each cell $\frac{(O-E)^2}{E}$

Then we have to do the summation $\chi^2 = \sum \frac{(O-E)^2}{E}$

Therefore, χ^2 is always UPPER ONE SIDED TEST

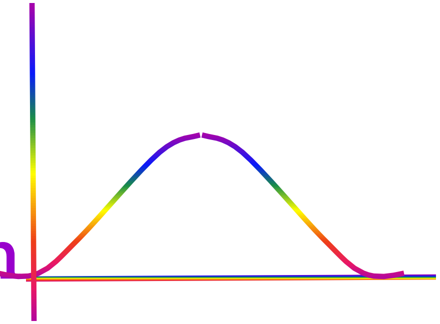
$$\chi^2 = \sum \frac{(O-E)^2}{E}$$



sign. Difference in proportion

Therefore, χ2 is always UPPER ONE SIDED TEST

Comparing calculated χ2 with tabulated χ^2 in relation to critical region



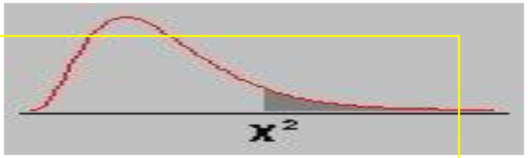
Critical region;

- **Level of significance 0.95, α = 0.05**
- **d.F = (No. of rows – 1) (No. of column – 1)**

  = (r – 1) (c – 1)

  (2 – 1) (2 – 1) = 1

	male	female	total
Present			
Absent			
total			



Chi square (χ^2)

It is the sum of the squared difference between the observed frequency and expected frequency, divided by the expected frequency .

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Chi square is

used in testing difference in proportions

while t test and F test are used in testing difference in means .

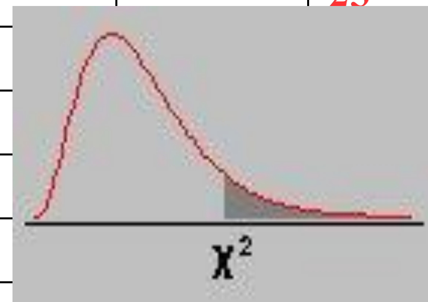
$$Ho = P_1 = P_2 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_0$$

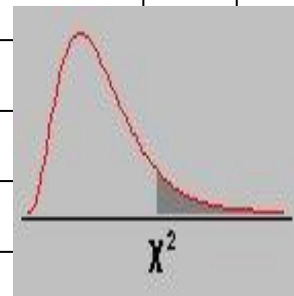
sign. Difference in proportion

Table of Chi-square statistics

df	P =0.05	P = 0.01	P = 0.001
1	3.84	6.64	10.83
2	5.99	9.21	13.82
3	7.82	11.35	16.27
4	9.49	13.28	18.47
5	11.07	15.09	20.52
6	12.59	16.81	22.46
7	14.07	18.48	24.32
8	15.51	20.09	26.13
9	16.92	21.67	27.88
10	18.31	23.21	29.59
11	19.68	24.73	31.26
12	21.03	26.22	32.91
13	22.36	27.69	34.53
14	23.69	29.14	36.12
15	25.00	30.58	37.70
16	26.30	32.00	39.25
17	27.59	33.41	40.79
18	28.87	34.81	42.31
19	30.14	36.19	43.82
20	31.41	37.57	45.32
21	32.67	38.93	46.80
22	33.92	40.29	48.27
23	35.17	41.64	49.73
[illegible]	36.42	42.98	51.18
[illegible]	37.65	44.31	52.62
[illegible]	38.89	45.64	54.05
[illegible]	40.11	46.96	55.48
28	41.34	48.28	56.89
29	42.56	49.59	58.30
30	43.77	50.89	59.70
31	44.99	52.19	61.10
32	46.19	53.49	62.49
33	47.40	54.78	63.87
34	48.60	56.06	65.25
35	49.80	57.34	66.62
36	51.00	58.62	67.99
37	52.19	59.89	69.35
38	53.38	61.16	70.71
39	54.57	62.43	72.06
40	55.76	63.69	73.41

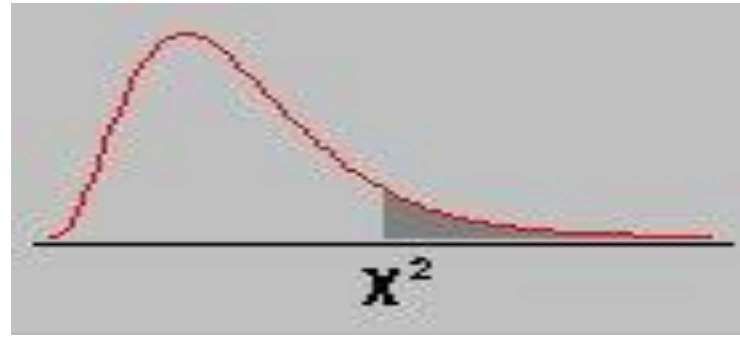


41	56.94	64.95	74.75
42	58.12	66.21	76.09
43	59.30	67.46	77.42
44	60.48	68.71	78.75
45	61.66	69.96	80.08
46	62.83	71.20	81.40
47	64.00	72.44	82.72
48	65.17	73.68	84.03
49	66.34	74.92	85.35
50	67.51	76.15	86.66
51	68.67	77.39	87.97
52	69.83	78.62	89.27
53	70.99	79.84	90.57
54	72.15	81.07	91.88
55	73.31	82.29	93.17
56	74.47	83.52	94.47
57	75.62	84.73	95.75
58	76.78	85.95	97.03
59	77.93	87.17	98.34
60	79.08	88.38	99.62



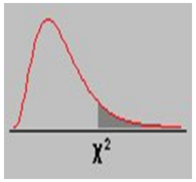
61	80.23	89.59	100.88
62	81.38	90.80	102.15
	82.53	92.01	103.46
	83.68	93.22	104.72
	84.82	94.42	105.97
	85.97	95.63	107.26
	87.11	96.83	108.54
68	88.25	98.03	109.79
69	89.39	99.23	111.06
70	90.53	100.42	112.31
71	91.67	101.62	113.56
72	92.81	102.82	114.84
73	93.95	104.01	116.08
74	95.08	105.20	117.35
75	96.22	106.39	118.60
76	97.35	107.58	119.85
77	98.49	108.77	121.11
78	99.62	109.96	122.36
79	100.75	111.15	123.60
80	101.88	112.33	124.84

81	103.01	113.51	126.09
82	104.14	114.70	127.33
83	105.27	115.88	128.57
84	106.40	117.06	129.80
85	107.52	118.24	131.04
86	108.65	119.41	132.28
87	109.77	120.59	133.51
88	110.90	121.77	134.74
89	112.02	122.94	135.96
90	113.15	124.12	137.19
91	114.27	125.29	138.45
92	115.39	126.46	139.66
93	116.51	127.63	140.90



93	116.51	127.63	140.90
94	117.63	128.80	142.12
95	118.75	129.97	143.32
96	119.87	131.14	144.55
97	120.99	132.31	145.78
98	122.11	133.47	146.99
99	123.23	134.64	148.21
100	124.34	135.81	149.48

Example



A sample of 671 diseased person were subjected to treatment, 354 individuals of them, were given drug A. Of those given drug A only 240 patients were survived. On the other hand only 212 patients *who's given drug B were survived can we conclude that the effectiveness of treatment differ* between two drugs (A&B) ????.Let α 0.05

Out come	**Drug A**	**Drug B**	Total
Survived	240	212	?????
Died	??????	????	?????
Total	354	?????	671

(**also known as a cross tabulation or crosstab**)

An important thing is the type of the variable concerned.

Out come	Drug A	Drug B	Total
Survived	240	212	452
Died	114	105	219
Total	354	317	671

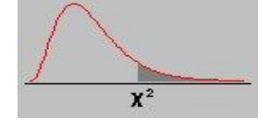
$$Ho = P_1 = P_2 = P_o$$

$$H_A = P_1 \neq P_2 \neq P_o$$

We would like to see if there ıs a **significance difference in** the **survival rate between the two drugs** . Let α 0.05

$$\text{Total Survival rate} = \frac{452}{671} \times 100 = 67.4\%$$

An important thing is the type of the variable concerned.



Survival rate for A $= \frac{240}{354} \times 100 = 67.8\%$

$$Ho = P_1 = P_2 = P_0$$

$$H_A = P_1 \neq P_2 \neq P_0$$

Survival rate for B $= \frac{212}{317} \times 100 = 66.9\%$

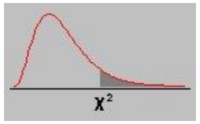
There is an **observed** **difference** in the survival rate between drug A (67.8%) and B (66.9%) .

Is this difference in survival rate due to

- Drug Effectiveness .
- Chance Factor .

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Out come	Drug A	Drug B	Total
Survived	240 (67.5%)	212(66.9%)	452(67.4%)
Died	114	105	219
Total	354	317	671



Data

Data consist of sample of patients divided into two groups, group A and group B .

Survival rate in group treated by drug **A** **was** **67.8 %,** **and** **Survival rate in group treated by drug B was 66.8%** .

Assumption

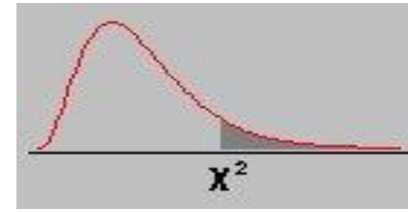
Two independent group of patients given two different type of treatment chosen randomly from normal distribution population .

Formulation of Hypothesis

Ho ???????????????

HA ????????????????????

Formulation of Hypothesis



Ho

There is no significance difference in the proportion (rate) of survival between two groups .

survival rate group treated by drug A was 67.8% &

survival rate group treated by drug B was 66.9%

There is no significance association between survival rate and type of treatment .

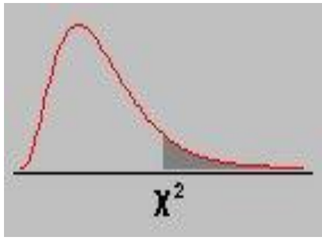
P1 = P2 = P0 : 67.8%=66.9%= 67.4%

HA

There is a **significance difference** in the survival **rate** between two type of treatment .

P1¬ ≠ P2 ≠ P0 .: 67.8%ǂ66.9%ǂ 67.4%

Survival rate is **higher among** group of patients treated by drug A .



Critical region

Level of significance 0.95, $\alpha = 0.05$

d.F =

(No. of rows – 1) (No. of column – 1)

= (r – 1) (c – 1)

(2 – 1) (2 – 1) = 1

tabulated χ^2 of d.F =1 with α 0.05 = 3.841

Outcome	Drug A	Drug B	Total
Survived	240	212	**452**
Died	114	105	**219**
Total	**354**	**317**	**671**

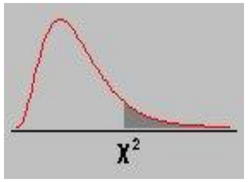
Proper test

Chi Square χ^2

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

$$E = \frac{total\ column \times total\ rows}{Grand\ \ total}\quad for\ each\ cell$$

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$



$$E_{240} = \frac{354 \times 452}{671} = 238.5$$

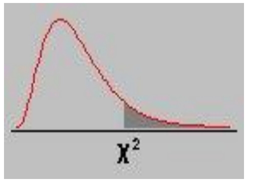
$$E_{114} = \frac{354 \times 219}{671} = 115.5$$

$$E_{212} = \frac{452 \times 317}{671} = 213.5$$

$$E_{105} = \frac{317 \times 219}{671} = 103.5$$

Outcome	Drug A		Drug B		Total
	O	E	O	E	
Survived	240	238.5	212	213.5	**452**
Died	114	115.5	105	103.5	**219**
Total	**354**		**317**		**671**

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$



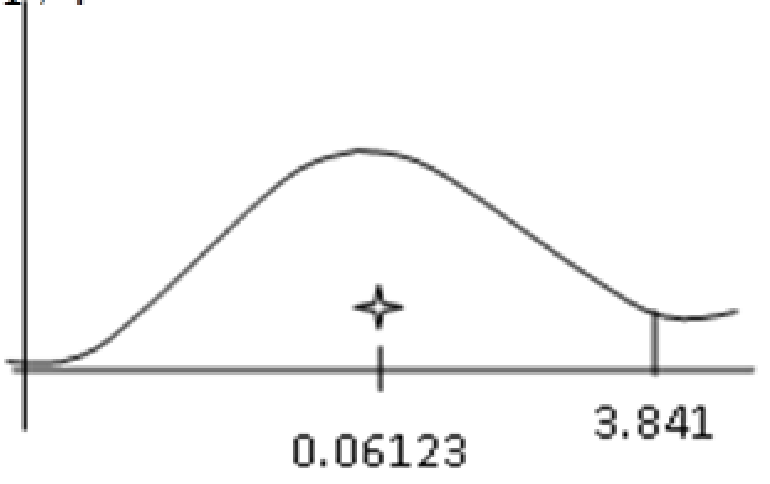
$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

$$= \frac{(240-238.5)^2}{238.5} + \frac{(114-115.5)^2}{115.5} + \frac{(212-213.5)^2}{213.5} + \frac{(105-103.5)^2}{103.5}$$

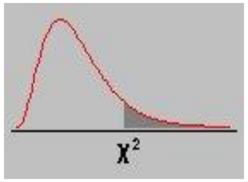
$$= \frac{(1.5)^2}{238.5} + \frac{(1.5)^2}{115.5} + \frac{(-1.5)^2}{213.5} + \frac{(1.5)^2}{103.5} = \frac{2.25}{238.5} + \frac{2.25}{115.5} + \frac{2.25}{213.5} + \frac{2.25}{103.5}$$

$$= 0.009434 + 0.0195 + 0.01056 + 0.02174$$

$$= 0.061234$$



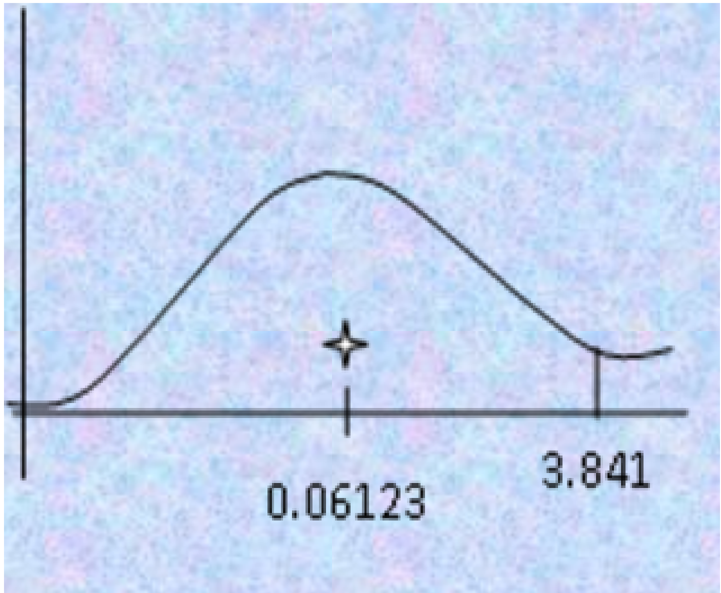
Calculated χ^2 fall in Accept Region → so
We **not reject** (accept) **Ho** .



There is no significance difference in proportion of survival rate between two drugs

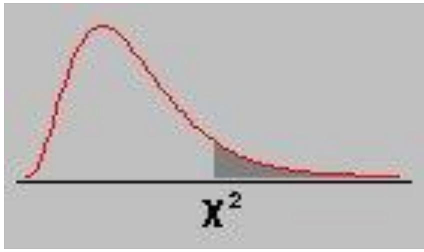
P > 0.05

Calculated χ^2 less than tabulated χ^2
chance factor increases,
influencing factor decrease



There is no significance effect of drug A to increase survival rate .
P > 0.05
.
P > 0.05 .

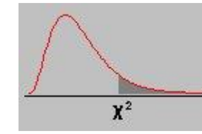
Chi square calculation procedure



- ✓ Calculate the expected values E for each cel
- ✓ Calculate the value O- E for each cell
- ✓ O is the observed
- ✓ Square $(O-E)^2$ Divide each squared O- E by E for each cell
- ✓ Sum all of the values in previous step

this result is called test statistic (calculated χ^2)

- ✓ identify the critical chi-square obtained
- ✓ from the chi square table.
- ❑ To reject the null hypothesis of equal proportion i.e. of independent variables the value of the test statistics must exceed the critical chi-square obtained from the chi square table.



Example 2

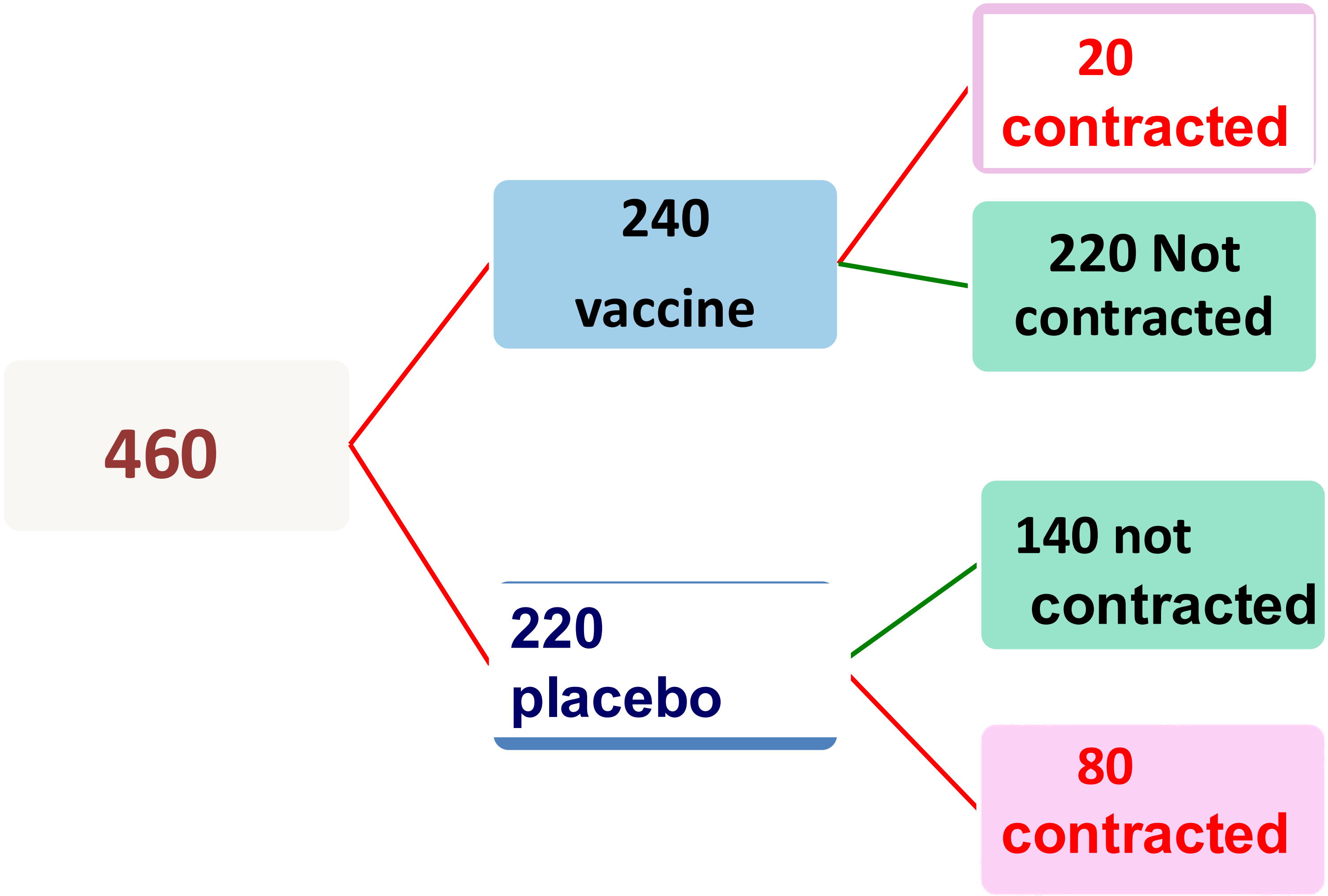
A sample of 460 adult was chosen , 240 were given influenza vaccine while the remaining given placebo Overall 100 persons contracted influenza, of whom 20 were in vaccine group .

we would like to assess the strength of evidence that vaccination affect the probability of contracting disease

is there any evidence that vaccine have an effect on contracting the disease ??

Total 460 → 100 persons contracted influenza

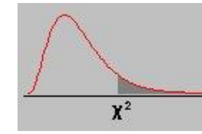
240 vaccinated → 20 contracted influenza



Total 460 → 100 persons contracted influenza

240 vaccinated → 20 contracted influenza

We start by display data in 2X2 table .



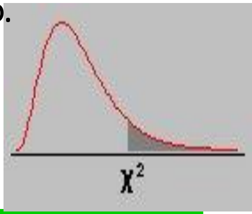
- **The exposure is vaccination (the row variable) and**
- **the outcome is contracting influenza (the column variable)**
- **we therefore include row % in the table**

Exposure	Out come +ve	Out come -ve	total
yes			
no			
Total			

(also known as a cross tabulation or crosstab)

A sample of 460 adult was chosen , 240 were given influenza vaccine while the remaining given placebo. Overall 100 persons contracted influenza, of whom 20 were in vaccine group .we would like to assess the strength of evidence that vaccination affect the probability of contracting disease .

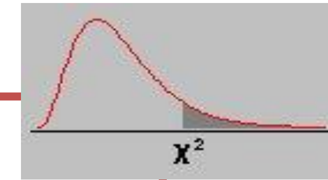
is there any evidence that vaccine have an effect on contracting the disease ??



Given	Contract influenza N %	Not contract influenza N %	Total
Vaccine	**20**	220	**240**
placebo	80	140	220
Total	**100**	360	**460**

We start by display data in 2X2 table .
The exposure is vaccination (the row variable) and the outcome is contracting influenza (the column variable)
we therefore include row % in the table

Total **460** → **100 persons contracted influenza**
240 vaccinated → **20 contracted influenza**



	Contract influenza N (%)	Not contract influenza N (%)	Total
Vaccine	**20 (8.3)**	**220 (91.7)**	**240**
placebo	**80 (36)**	**140 (63.6)**	**220**
Total	**100 (21.7)**	**360 (78.3)**	**460**

Overall persons contracting influenza

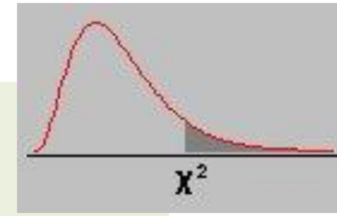
100/460= 21.7%

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

The chi square compare the observed number in each of four categories with the number expected

E = Total row X total column / Over all total frequency

E expected (E) = $\frac{\text{total column X total row}}{\text{Grand total}}$



E20 = $\frac{240X\ 100}{460}$=

E220 = $\frac{240X\ 360}{460}$=

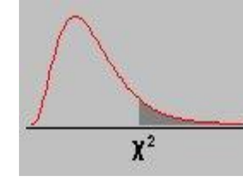
E80 = $\frac{220X\ 100}{460}$=

E140 = $\frac{220X\ 360}{460}$=

	Contract influenza N (%)	Not contract influenza N (%)	Total
Vaccine	20 (8.3)	220 (91.7)	240
placebo	80 (36)	140 (63.6)	220
Total	100 (21.7)	360 (78.3)	460

E expected (E) = total column X total row / Grand total

$$E = \frac{\text{total column} \times \text{total row}}{\text{Grand total}}$$

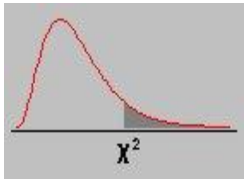


The chi square compare

the observed number in each of four categories with the number expected

	Contract influenza		Not contract influenza		total
	O	E	O	E	
Vaccine	20	52.2	220	187.8	240
placebo	80	47.8	140	172.2	220
Total	100		360		460

Then chi square be calculated by calculating E. frequencies



if there were no difference in the efficacy between vaccine and placebo.

if the vaccine and placebo having same efficiency then

Then chi square be calculated by calculating E. frequencies

we expect to have same proportion in each group that is in the

vaccine group 100/460 X 240= 52.2

in placebo group 100/460 X 220 **= 47.8**

H0= **52.2 =47.8**

would have contract influenza. .

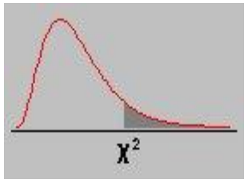
Similarly

360/ 460 x240=187.8 in vaccine group

360/460 X 220 =172.2 in placebo group

will escape influenza

$$X^2 = \sum \frac{(O - E)^2}{E} \qquad d.f. = 1$$



	Contracting Influenza O	Contracting Influenza E	Not contract influenza O	Not contract influenza E	total
Vaccine	20	52.2	220	187.8	240
placebo	80	47.8	140	172.2	220
Total	100		360		460

$$X^2 = \frac{(20 - 52.2)^2}{52.2} + \frac{(80 - 47.8)^2}{47.8} + \frac{(220 - 187.8)^2}{187.8} + \frac{(140 - 172.2)^2}{172.2}$$

$$19.86 + 21.69 + 5.52 + 6.02 = 53.99$$

compare calcul. With tabulated

Critical region

d.F = (C – 1) (r – 1)

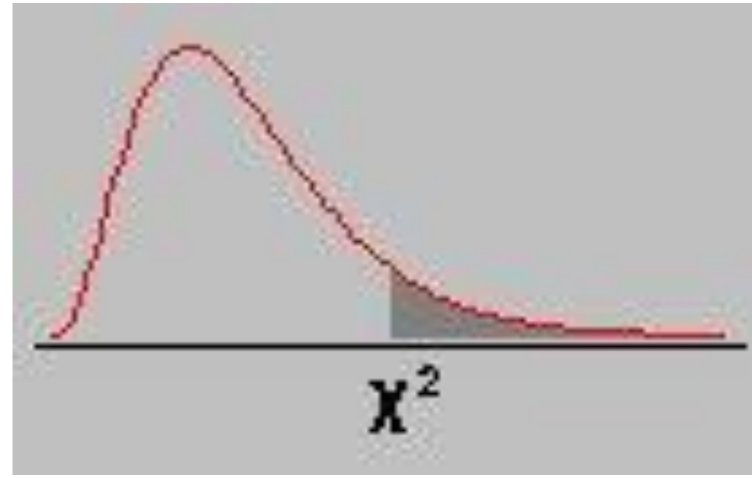
= (2 – 1) (2 – 1) = 1

$\alpha = 0.05$

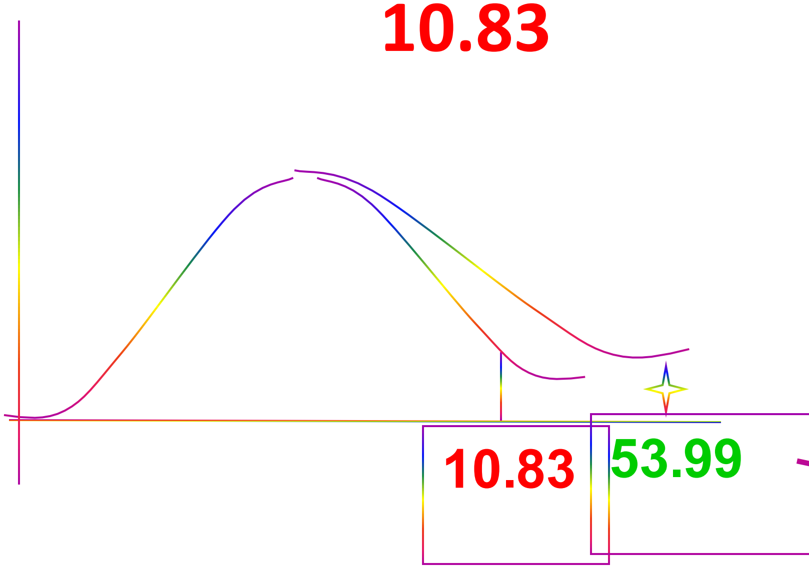
tabulated χ^2 = 3.84

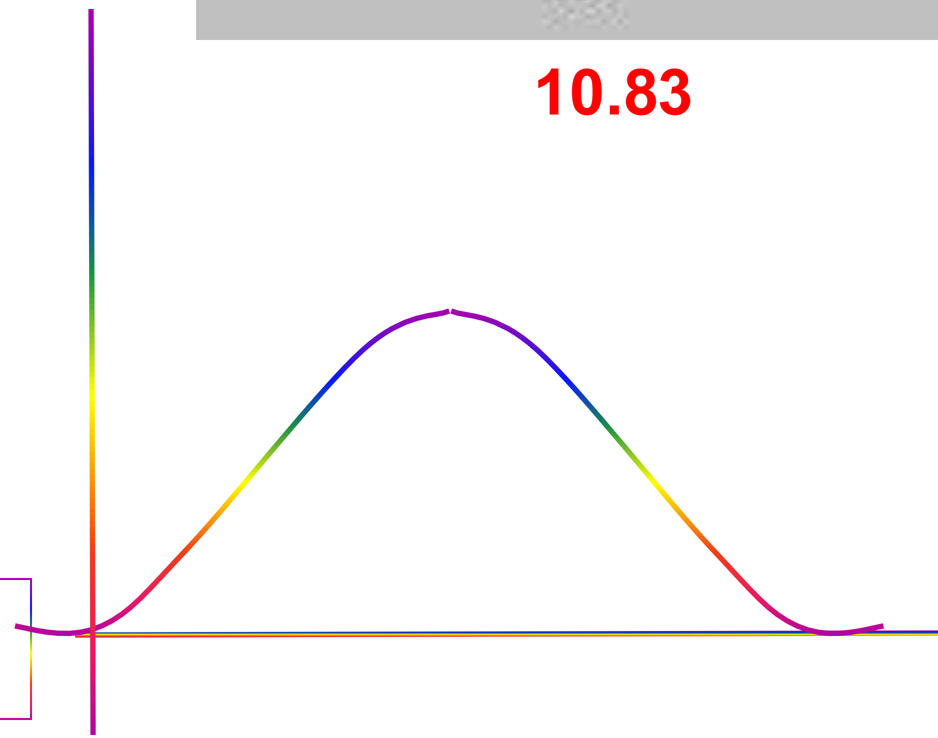
6.64

10.83



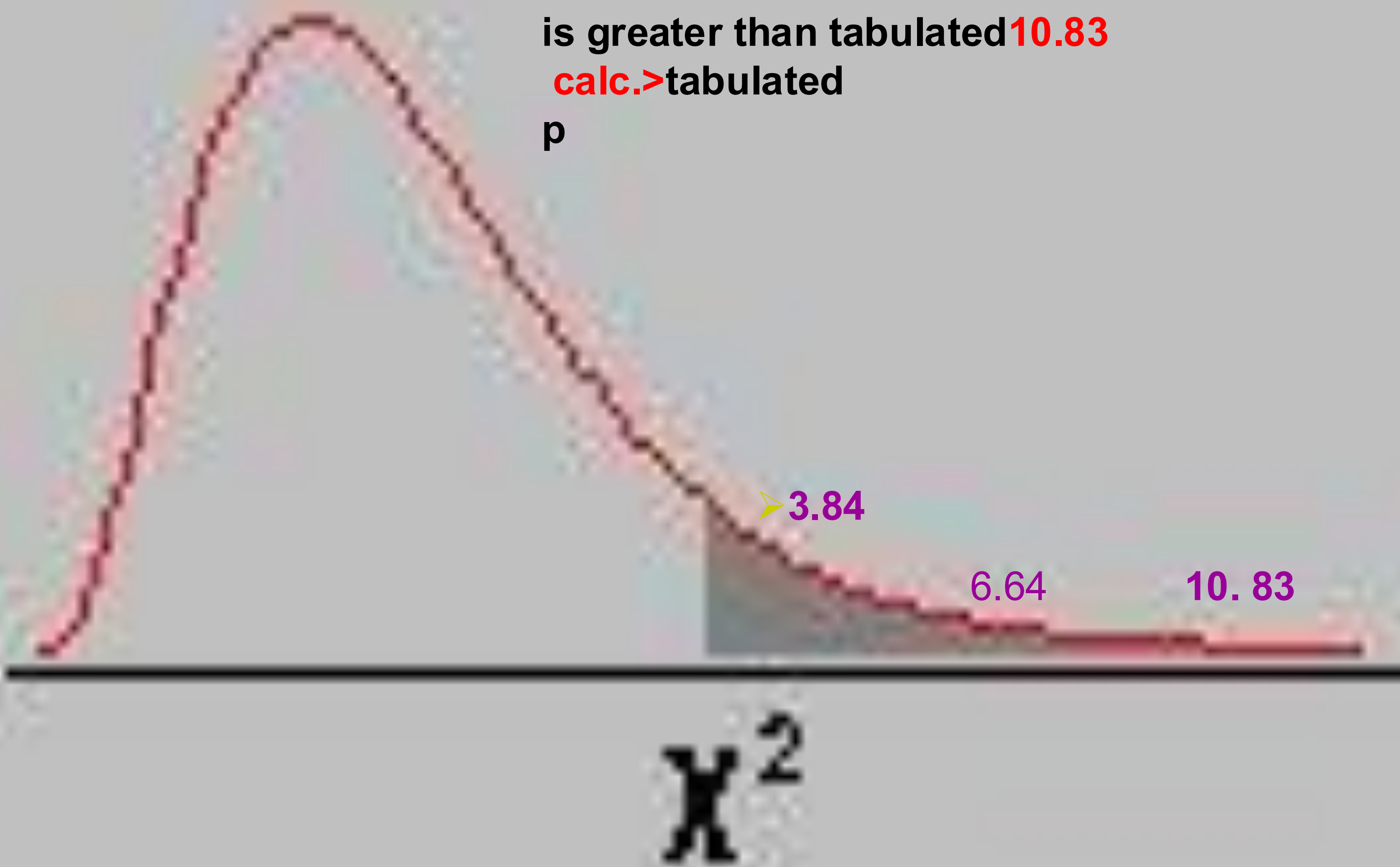
10.83





your χ^2 53.99
Accept
95%
0.95
P=0.05
$\chi^2 = 3.84$
Reject
Reject
006 010 0.030. 0.04.05
0.05 0.040.020.010.00
P

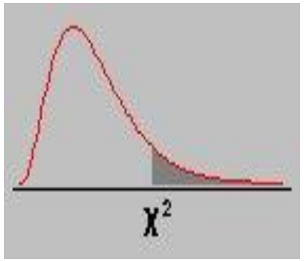
calculated 53.99
is greater than tabulated 10.83
calc.>tabulated
p



53.99

p is ?????????

- This mean that
- the probability (p) is less than 0.001
- that chance factor has effect much less than 0.001



- and more than 99.999 that this difference
- due to vaccine

- Thus there is a strong evidence against null hypotheses that is saying no effect of vaccine on the probability of contracting influenza .

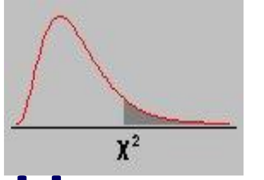
- there is a strong evidence that vaccine is effective

- Therefore it is concluded that vaccine is effective

Continuity Correction

The chi square test for 2X2 table can be improved by using continuity correction we call it Yates continuity correction the formula become

$$X^2 = \sum \frac{[(O - E) - 0.5]^2}{E} \qquad d.f. = 1$$



Pearson's chi-squared test by subtracting 0.5 from the difference between each observed value and its expected value in a 2 × 2

Resulting in small value for chi square (the value of O –E) ignoring the sig

$$X^2 = \frac{(20-52.2-0.5)^2}{52.2} + \frac{(80-47.8-0.5)^2}{47.8} +$$

$$\frac{(220-187.8-0.5)^2}{187.8} + \frac{(140-172.2-0.5)^2}{172.2}$$

$$X^2 = \frac{1004.89}{52.2} + \frac{1004.89}{47.8} + \frac{100.89}{187.8} + \frac{1004.89}{172.2}$$

$$X^2 = 51.46$$

Thank You

Example III

A sample of 84 mother chosen randomly **20** were smoker who delivered **14** babies with small birth weight (BW) .While the non smoker women delivered **20** small BW babies .can we conclude that maternal smoking has a relation to small birth weight ?

Application of χ2.

1. **2 × 2 table .**
2. **a × b table .**

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$