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# Analysis of male persons did slightly more infected than female persons with COVID-19

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**Abstract**--The Z-test is a hypothesis testing tool that can be used to detect whether a mean result for large population is statistically significant the population is normal distribution. It is a statistic based approach which is used to identify whether we can approximate the given distribution by a distribution which is normal. It is used to identify whether means of two samples are approximately the identical or different. It is useful when the size of the sample is large (should be  $\geq 30$ ). In this paper we apply Z-test on large covid-19 infected population for Indore city. From the large population covid-19 infected population it is difficult to check and identify that how many male and how many female persons are infected. Large numbers of tests are conducted for suspected male and female person for covid-19. There are so many statistical tools available to analyze the data set but it is difficult to select tool. Using Z-test we want to check that male persons did slightly more infected than female persons with Covid-19. We calculate test statistics and values of Z and compare it with standard normal distribution for Z value. We used random sample size for both male and female persons.

**Keywords**--hypothesis testing, chi square, COVID-19, population, Z test, normal distribution.

**Introduction**

Z-test is a statistical method which is used to compare and determine the importance of some measures, specifically the given mean of two independent random samples are normally distributed population. It can be performed only for those samples which are normally distributed. It is based on the theory where

all key points on the random sample are independent. In a normal distribution, the average is reflected 0 and the variance as 1. Mean in z-test can also be used to compare the population proportion. It is more suitable as it has the same critical value for different random sample sizes [7, 8, 20, 23].

It is a statistic based experiment which describes whether means of two populations are identical or different. In Z-test we have already know value of variances and suitable for large random sample. It is a hypothetical test where z-statistic has normal distribution. Two value z statistic and z score is used to characterize test. It t-tests and z test are closely related but main difference is that t-tests are best form small sample size. It is the most frequently used statistical tool in research methodology where, z-score is a number which define standard deviations above or below the mean of the population. Different type of Z-test is used for different purpose. Some of them are given below [7, 15, 18, 22].

### Single proportion

With the help of single proportion we test a hypothesis for a specific value of the sample size. For single proportion we define null hypothesis as

$$H_0: p = p_0$$

Against the alternative hypothesis

$$H_1 = p >< p_0$$

Where

p denotes proportion of population

$p_0$  denote a specific value

### Single mean

Single mean is used when we want to test a hypothesis for a precise value for the given population mean. The null hypothesis is tested as

$$H_0: \mu = \mu_0$$

The alternative hypothesis can be tested as

$$H_1: \mu >< \mu_0$$

$\mu$  denotes mean for the population and  $\mu_0$  denotes a specific value for the population.

### Single variance

Single variance is used to test hypothesis for a precise value of variance for given the population. The null hypothesis is tested as

$$H_0: \sigma = \sigma_0$$

The alternative hypothesis can be tested as

$$H_1: \sigma >< \sigma_0$$

Where  $\sigma$  the population is mean and  $\sigma_0$  is a precise value of the population to test for acceptance.

### Terminally used with Z test

To find value of z statistic we need to compute the values [11, 14, 19,21,17]

### Sample pooled proportion

we calculate value of sample pooled proportion ( $\hat{p}$ ) using the formula given below. This value helps us to calculate the standard error distribution.

$$\hat{p} = \frac{(p_1 \times n_1 + p_2 \times n_2)}{(n_1 + n_2)}$$

Where

$p_1$  Sample proportion for first population

$p_2$  Sample proportion for second population

$n_1$  Denotes size of first random sample,

$n_2$  Denotes of second random sample

### Standard error

We need to calculate Standard error (SE) by using given below formula. This will for sampling distribution between two proportions

$$\widehat{SE}_{dif} = \sqrt{\hat{p}(1 - \hat{p}) \times \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

Where

$\hat{p}$  Denotes sample pooled proportion

$n_1$  Denotes size of first random sample

$n_2$  Denotes size of second random sample .

### Difference between random sample proportions

Difference between sample proportions and denote as *dif* and calculated by the formula

$$dif = p_1 - p_2$$

### Z Statistic

The z statistic is a value of z-score (z) which can be defined by the following equation.

$$Z = \frac{dif - \delta}{\widehat{SE}_{dif}}$$

Where

$\delta$  Denotes the hypothesized population

$\widehat{SE}_{dif}$  Denotes standard error

## P Value

The P-value defined as the probability of detecting size of sample for test statistic. The test statistic value is denoted by the z-score, we can use distribution calculator to measure the associated probability.

## Rules for Z test

The rules for independent proportions for z test contains

- Observations are purely independent
- Size of random sample satisfactory.

Declare the test outcomes are sufficiently accurate when satisfied

$$p_1 \cdot n_1 > 5$$

$$(1 - p_1) \cdot n_1 > 5$$

$$p_2 \cdot n_2 > 5$$

$$(1 - p_2) \cdot n_2 > 5$$

Where

$p_1$  Random sample proportion for first population

$p_2$  Random sample proportion for second population

$n_1$  Size of sample for first population

$n_2$  Size of sample for second population

Following situations are essential to accomplish a z-test for means  $\mu_1$  and  $\mu_2$  two populations. The samples size should be randomly selected. The used random samples size need to be independent. Two random samples size are independent if the one sample chooses from population then one is not associated to the sample chooses from the second population. Each sample size we must have minimum 30 or higher sample size with a known standard deviation

## Literature review

We have study some of the paper related with our research paper. In 2010 Jonathan Arnold et al proposed "Predicting Successful Aging in a Population-Based Sample of Georgia Centenarians". They showed 11 chronic diseases which fall into two morbidity clusters. These diseases pose three key obstacles to effective aging. Almost 43 percentages of the centenarians did not prepare dementia. Practically 17 percentages of the GCS centenarian has chronic disease, although 36 percentage dawn. These delayers and survivors as forecast for the median life foreexpectation of 100 populations. The caveats on such a guess contain no group effects outside those important to the increase in life expectation of 2.5 years decade [1].

In 2011 B. Weaver proposed "Hypothesis Testing Using z- and t-tests". To explain the concepts of z test and t test they apply two most important ideas the first one is sampling distributions of statistical data and second the is use of central

boundary theorem. The approximation of t-test is poor if the populations sampled are too far from normal distribution. Significance of leaving from regularity is inversely associated to sample size. Parting from regularity is the most grievous when the size of sample are too small, and converts less serious when the size of the sample increase. Normality tests have short power to perceive parting from normality for the small sample sizes [2].

In 2012 Lutz Bornmann et al proposed “Statistical Tests and Research Assessments: A comment on Schneider”. They used statistical analysis and effective measures to evaluate ranking. Accordingly to size measures were added into Excel sheets and apply online testing performance. They Identify difference between institutions in Ranking and SCImago Institutions Ranking. They suggested statistical analysis and effect measures, but do not replace significance testing [3].

In 2012 Donald W. Zimmerman et al proposed “Correcting Two-Sample z and t Tests for Correlation: An Alternative to One-Sample Tests on Difference Scores”. They presented a study and discovered a substitute approach. They changed test for two-sample by applying with aim improvement in the correlation, equivalent. For distributions which is not normal they used similar improved test and completed data on rank-transformed. They used recreation process to defend the error of Type I and moderate rate sizes and for normal distributions. They found that error of Type I rate reduce for sample of small sizes. The modified test is substitute for the statistical tests available and provides theoretical interest [4].

In 2013 Sean Wallis et al proposed “z-squared: The Origin and Application of chi square”. They compare likelihood tests for discrete nature of distributions. Whole data set separated into more than two alternate groups. They discussed mathematical underpinnings of these tests and apply these tests appropriately; they saw the likelihood of testing specific questions. They showed that possibility tests are thoroughly related for construction of self-reliance rests. They showed the test for homogeneity for two observations and tested for larger tables [5]. In 2014 Daniel Granato et al proposed “Observations on the use of statistical methods in Food Science and Technology Statistical methods”. They presented the important of univariate and bivariate parametric techniques and highlighted their uses. They also discussed fundamental necessities for use of statistic based tests to understand benefits and drawbacks in useful applications. They explained the use of collective statistic based tests to analysis data which are used in Food Science [6].

In 2015 Asyraf Afthanorhan et al proposed “A Parametric Approach Using Z-Test for Comparing 2 Means to Multi-Group Analysis in Partial Least Square Structural Equation Modeling (PLS-SEM)”. They used probability sampling and statistical assumption. They intended and demonstrated a parametric approach with the help z-test. They compared means to achieve value of z-scores. They demonstrated the z-test with Smart Pls 2.0 software. They implemented and analysis the needs for z-test population proportion along with the p-value [7]. In 2015 Nikolaos Pandis et al, proposed “Comparison of 2 means (independent z test or independent t test)”. They discussed and demonstrated how to compute the probability of data for observed population. They used information to conduct z

test and t test for different sample size to see the evidence. They compared means for two samples which are independent and apply z test. They used two independent groups based on normal distribution compared the means using a z test. They assumed the random sample size has equal and standard deviations where not known [8].

In 2016 Siti Aisyah Zakaria et al proposed "Performance of undergraduate engineering students in mathematics according to gender". They explore the academic performance between genders based on CGPA. They observe the influence of gender to academic performance. They used a random sample of 1000 engineering students. They used descriptive statistics and presented the main characteristics. The result of z-test method is significantly different across the gender for 3 years. They attempted to explore performance of engineering students between different genders in the course of Mathematics [9].

In 2016 Sander Greenland Stephen et al proposed "Statistical tests, P values, confidence intervals, and power: a guide to misinterpretations". They validated a resource for trainers, investigators, and customers of statistics. They discovered information of statistical theory and procedure. They request to escape and spot misconceptions. They highlighted how destruction of repeatedly unspecified investigation practices such as choosing evaluation for performance created on the P values. They created minor P values equal to the acknowledged hypothesis is right [10].

In 2017 Boshu Ru et al proposed "Evaluation of the informatician perspective: determining types of research papers preferred by clinicians". They collected data from different websites and around 96 clinical and approximately reviewed 6,221 articles. They observed and compared the deliveries of MeSH terms. They determined and followed the sampled clinical up-to-date literature. They favored to read systematic findings from human tests instead of testing the model based on molecular, cellular and animal experiments [11].

In 2018 Daniel Lakens et al proposed "Equivalence Testing for Psychological Research: A Tutorial for Psychologists". They described a variety of methods to define psychological knowledge. They explained and provide complete similarity tests that can be reported. Correspondence tests are used for significant extension of the statistical implements. In some situations research, researchers can use similarity tests and basically discard repeatedly smaller effects. They showed the importance of not identifying an exploration query which hinders theoretical progress [12].

In 2019 Frank Emmert Streib et al proposed "Understanding Statistical Hypothesis Testing: The Logic of Statistical Inference". They discuss the logic behind statistical hypothesis testing. They provided an introduction on statistical hypothesis testing. They do not use domain specific formulations for commands to make the transference of information. They used many practical applications and perform multiple hypothesis tests simultaneously. They also showed situations where requests to apply a several testing for directing errors [13].

In 2019 Jay J. Van Bavel et al proposed “Using social and behavioural science to support COVID-19 pandemic response”. They discussed and showed the proof from a collection of research areas. They identify numerous acumens for activereply to the COVID-19. They argued 3 keyissues stand in the for anticipation first is persons do not escalate the dangers they track second goes alongside socialenvironment for persons to locked themselves up in rigidseparation as a means of defensive others, and third personsregularly unintentionally performance as a remaining risk to themselves and others. They provide certain intuitions from the earlier work on connectedproblems. They discussed threat awareness, social situation, and science message and cooperative welfares [14].

In 2020 Edward Volchok et al proposed “Statistics: Module 15: Two-Sample Null Hypothesis Significance Tests”. They covered one-sample hypothesis tests in and move on to two-sample hypothesis tests. They reviewed6dissimilar statistical implication tests expending distributions of z value , distributions of t value, and distributions of F value. They differentiated between samples of independent size and sample of dependent size to conduct z-test. They measured the magnitude of the effect. They estimate Type II error for z test for2 sample and table of t test. By using charts ofthe normal distribution they proposed conclusion approximately the outcomesof null hypothesis [15].

In 2021 Frank Wang et al proposed “Using COVID-19 Vaccine Efficacy Data to Teach One-Sample Hypothesis Testing In late November 2020”. They described the idea of hypothesis testing and how to construct hypothesis. Instead of using 2 sample test they used proportion of one side for z-test and analyzed the data. They justified the use of z-distribution and approximated for the confidence interval to improve efficacy rate. They demonstrated the information obtained from numbers related trials reported in the media. They simplified the hypothesis testing for students with simple statistical exercise can recognize [16].

### **Step used to perform Z test analysis**

The following six steps are for a Z-test:

1. Declare the hypotheses: The first we need to declare the hypothesis both null alternative hypothesis.  
We denote them as Null hypothesis: With a statement  
We denote them as Alternative hypothesis: with opposite of first statement  
The first hypothesis need to reject if the amount from populace one is too large or if it is very small.
2. Check all assumptions required for to perform test:
  - Observations which are used to perform the test must be independent
  - Samples which are used to perform the test must have sufficient size.

Following equations are need to satisfy for the test and the results are applicably accurate if

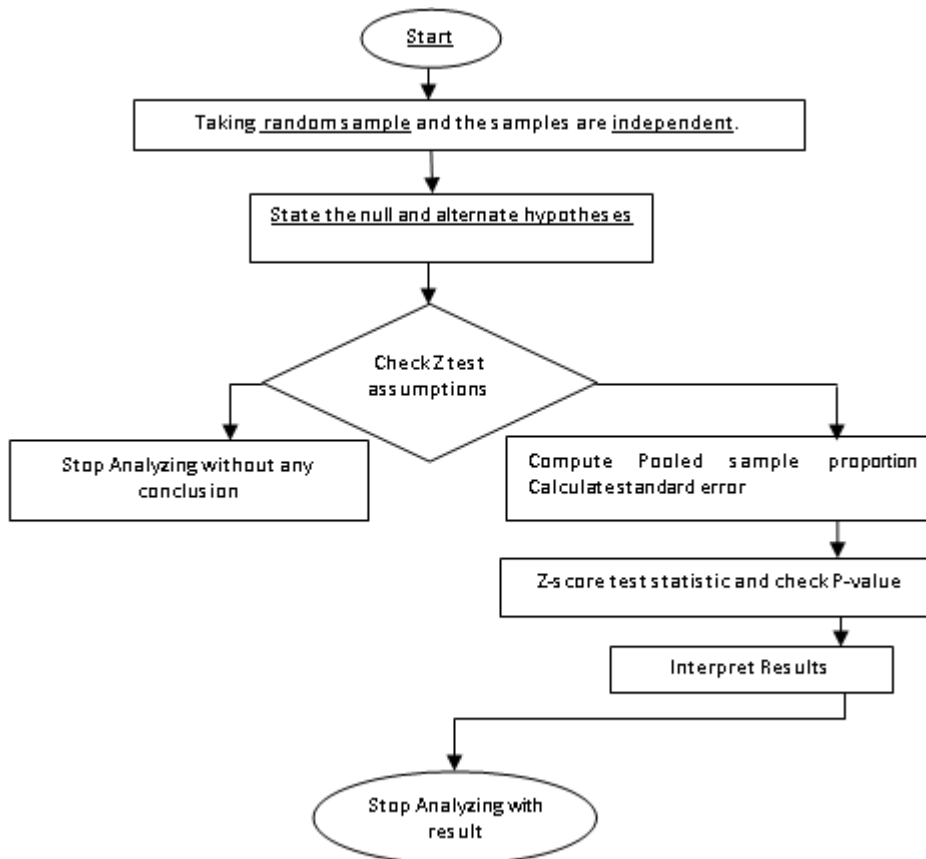
$$\begin{aligned} p1.n1 &> 5 \\ (1 - p1).n1 &> 5 \\ p2.n2 &> 5 \end{aligned}$$

$$(1 - p_2) \cdot n_2 > 5$$

3. Calculate pooled proportion for random sample: Calculate pooled proportion for sample from the given population and sample proportion from the population.
4. Find out standard error: Calculate standard error denoted by SE for the distribution sample and difference among given proportions by the using the standard error (SE) formula.
5. Calculate Z test statistic: With the help of the pooled proportion which is denoted by  $p$  and by using standard error (SE), compute the test statistic value.
6. Find out P-value: The P-value is known as the probability for detecting sample is random for test statistic. Since the test statistic is denoted by  $z$  value, we used calculator of normal distribution to measure the probability related with the  $z$  value.
7. Infer Results: Random sample are found to be unlikely with given null hypothesis, discards the null hypothesis. P-value is compared with the significance level, and refusing the null hypothesis if P-value is smaller with significance level.

### Outline of Proposed Approach

The proposed approach has following outline



**Illustrate with example****State null hypothesis**

Male Persons did slightly More Effectuated than Female Persons Consider a simple example

A random sample of  $n_1 = 175$  Female and  $n_2 = 164$  Male persons has been selected for Covid-19 test. The data shown below are used for test of independent proportion.

Table 1 Sample population's independent proportions

		Female		Male		Total	
		Count	%	Count	%	Count	%
Covid-19	Not Infected	49	28.0%	38	23.2%	87	25.7%
	Infected	126	72.0%	126	76.8%	252	74.3%
	Total	175	100.0%	164	100.0%	339	100.0%

Here

$$n_1=175$$

$$p_1=0.720$$

$$n_2=164$$

$$p_2=0.768$$

Percentages of Male and Female persons infected with COVID -19 are represented by a contingency table.

- Value of  $p_1 = 0.720$  out of  $n_1 = 175$  denoted for female
- Value of  $p_2 = 0.768$  out of  $n_2 = 164$  denoted for male.

In example we selected random sample and want to check that male persons did slightly more effectuated than female persons. Although entire male and female populations achieve equally. The z-test attempts to validate the hypothesis and thus determine that the people really do perform differently.

**Null Hypothesis**

The null hypothesis can be determined for test of independent proportions is that "the population difference between 2 proportions is zero". Conclusions that are very dissimilar from zero are unlikely and we can thus argue against the null hypothesis.

**Assumptions**

Check all assumptions required for to perform test:

- Observations which are used to perform the test must be independent

- Samples which are used to perform the test must have sufficient size.

Following equations are need to satisfy for the test and the results are applicably accurate if

$$\begin{aligned}p1.n1 &> 5 \\(1 - p1).n1 &> 5 \\p2.n2 &> 5 \\(1 - p2).n2 &> 5\end{aligned}$$

All assumptions are true for given sample size.

### Z-Test computing

For computing our test value, we must compute the difference among sample proportions by using the formula

$$dif = p1 - p2$$

In the given sample

$$dif = 0.720 - 0.768 = -0.048$$

The standard error is depends on the population proportion. Population proportion can be calculate with the help of the formula

$$\begin{aligned}\hat{p}(\text{pooled population proportion}) &= \frac{p1.n1 + p2.n2}{n1 + n2} \\ \hat{p} &= \frac{(0.720 \times 175) + 0.768 \times 164}{175 + 164} \\ \hat{p} &= 0.743 \\ \hat{p} &= 0.743\end{aligned}$$

Note that this is simply the overall proportion of sample (male and female) those are infected from Covid-19. This is readily verified in the contingency table. Standard error can be calculated by using the formula

$$\begin{aligned}\widehat{SE}_{dif} &= \sqrt{\hat{p}(1 - \hat{p}) \times \left(\frac{1}{n1} + \frac{1}{n2}\right)} \\ \widehat{SE}_{dif} &= \sqrt{0.743(1 - 0.743) \times \left(\frac{1}{175} + \frac{1}{164}\right)} \\ \widehat{SE}_{dif} &= 0.047\end{aligned}$$

Finally we can compute our test statistics value

$$Z = \frac{dif - \delta}{\widehat{SE}_{dif}}$$

Where hypothesized population difference is denoted by  $\delta$ . Our population are equal so that states that  $\delta = 0$ . So for our example,

$$Z = \frac{-0.048 - 0}{0.047}$$

$$Z = -1.02$$

If the test assumptions are completely met, then z value approximately follows a standard normal distribution. We can see test value form the standard calculator that

$$P(Z < -1.02) = 0.155$$

for 2-tailed significance is

$$P(2 - \text{tailed}) = 0.309$$

Conclusion: We accept null hypothesis statement “Male Persons did slightly More Effected than Female Persons”.

Table 2 standard z test table

Z	Left tail probability	Right tail probability	2-tailed probability
-4	0.000	1.000	0.000
-3	0.001	0.999	0.003
-2	0.023	0.977	0.046
-1	0.159	0.841	0.317
0	0.500	0.500	1.000
1	0.841	0.159	0.317
2	0.977	0.023	0.046
3	0.999	0.001	0.003
4	1.000	0.000	0.000

## Implementation Environment



Figure 2 implementation snapshot of proposed approach

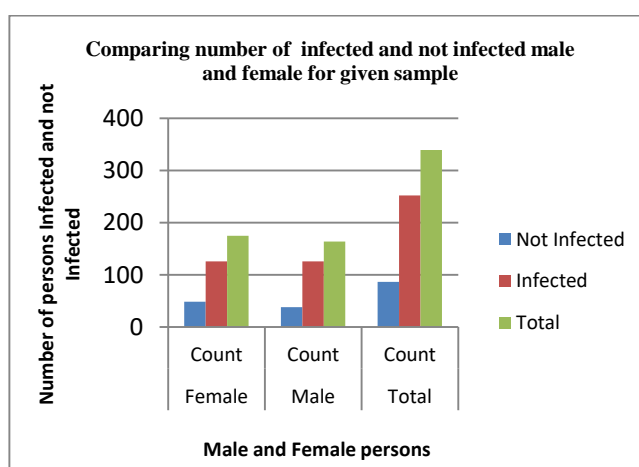
## Result and Analysis

### Comparing based on male and female infected with COVID-19

Form the table 3 we can see from 175 female persons, 126 is infected and 49 is not infected ,similarly we can see that from 164 male person , 126 is infected and 38 is not infected . Graph 1 shows that total form sample 339 (male and female) 87 not infected and 252 infected

Table 3 Comparing Number of male and female infected with COVID-19

Covid-19	Female	Male	Total
Not Infected	49	38	87
Infected	126	126	252
Total	175	164	339



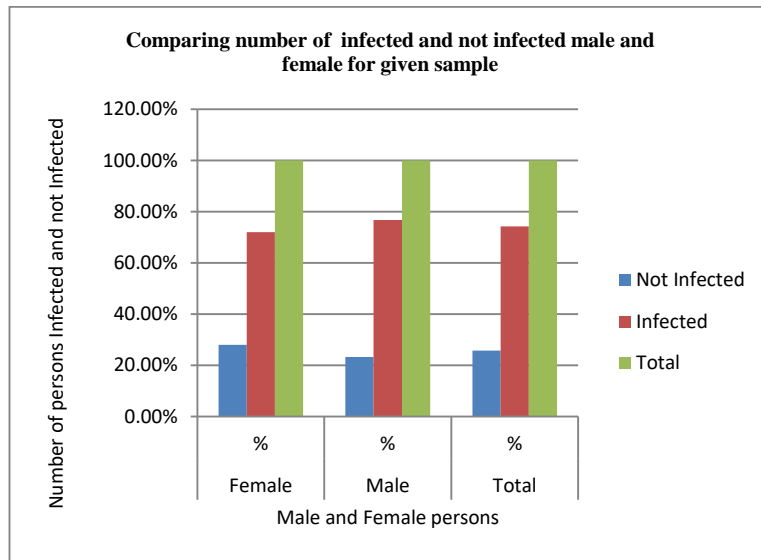
Graph 1 Comparing Number of male and female infected with COVID-19

### Comparing percentage of male and female infected with COVID-19

Table 4 shows that form female person 28% not infected and 72% infected, similarly we can see that from 23% of male person not infected and 76% infected. From graph 2 it is clear that percentage wise number of male person is higher infected as compare to female person.

Table 4 Comparing percentage of male and female infected with COVID-19

Covid-19	Female	Male	Total
Not Infected	28.00%	23.20%	25.70%
Infected	72.00%	76.80%	74.30%
Total	100.00 %	100.00 %	100.00 %



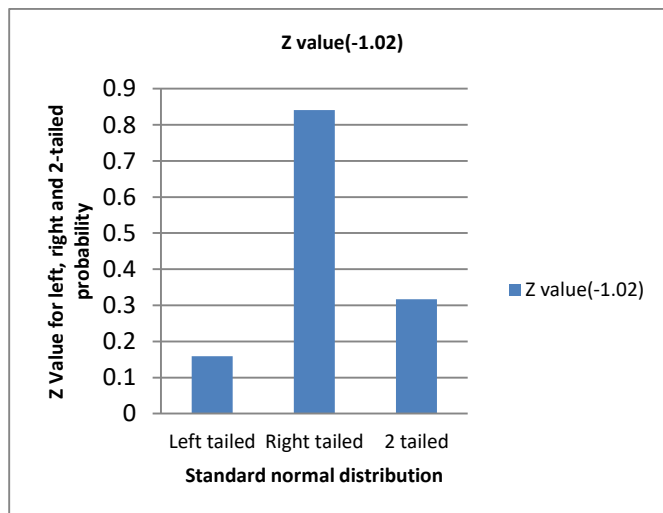
Graph 2 Comparing percentage of male and female infected with COVID-19

**Comparing test value the, Left, Right and Two tailed**

Table 5 shows that for calculated test value the, Left, Right and two tailed value form the standard z distribution.

Table 5 Comparing Z value the, Left tailed, Right tailed, Two tailed

Z value	Left	Right	Two tailed
-1.02	0.159	0.841	0.317



Graph 3 Comparing Z value the, Left tailed, Right tailed, Two tailed

## Conclusion

We have taken 1000(Male) and 1000(Female) suspected person with COVID-19 We used random sample from the given population. We have taken 175 female persons and 165 Male persons which are selected for Covid-19 test. We can see that out 175 female people 126 are to be found infected and 49 are to be found not infected. Similarly we can see that out of 126 male persons 126 are to be found infected and 38 are to be found not infected. Using Z test we want check that Male persons did slightly more infected than female Persons with Covid-19, for this we calculate Pooled proportion is calculated with the help of  $p_1$  is the sample proportion from population 1  $p_2$  is the sample proportion from population 2,  $n_1$  is the size of sample 1,  $n_2$  is the size of sample 2. Next we calculate value for difference between sample proportions. The z value is calculated with the help of Compute difference between sample proportions, hypothesized population and the standard error of the sampling distribution. by the experimental analysis and comparison of Z test values with standard normal distribution for Z statistics we found that the Male person is highly infected as compared to female persons.

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