

Lab 3 Statistical Inference

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1. Call to a Firm in an hour.
2. Number of Traffic accidents.
3. Number of arrivals in a restaurant in a day.

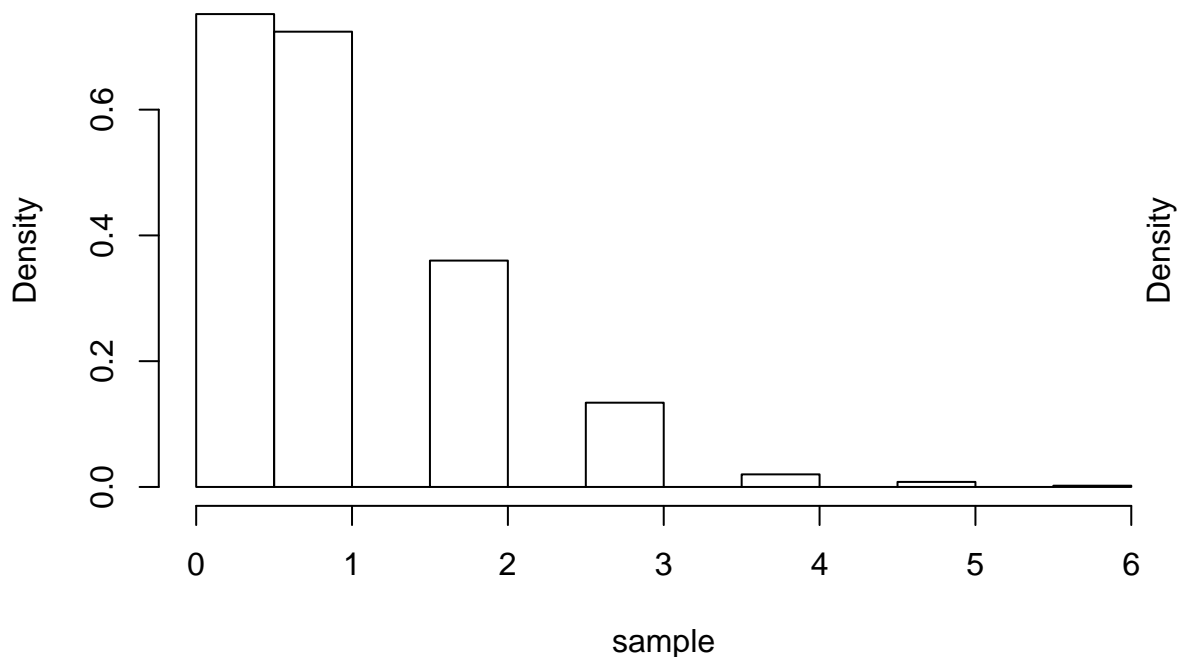
```
calculate_ci <- function(sample_data, level_confidence)
{
  if(length(sample_data) < 30)
  {
    print("Sample data size should be atleast 30 for satysifing the CI conditions")
  }
  else
  {
    z <- qnorm((1 - level_confidence)/ 2) * -1
    mean_sample <- mean(sample_data)
    sd_sample <- (sum((sample_data - mean_sample) ^ 2)) / (length(sample_data) - 1)
    me <- sd_sample / sqrt(length(sample_data))
    lower_tail <- mean_sample - me * z
    upper_tail <- mean_sample + me * z
    print(paste("lower tail is :", lower_tail))
    print(paste("upper tail is :", upper_tail))
    return(upper_tail - lower_tail)
  }
}
```

```
two_tail_z_dist_mean_hyp_test <- function(sample_data, null_value, alpha)
{
  if(length(sample_data) < 30)
  {
    print("Warning: the data size is not enough for satysfing the CLT condition")
  }
  p_value <- t.test(sample_data - null_value, alternative = "two.sided", conf.level = 1 - alpha)$p.value
  print(paste("P value is: ", p_value))
  if(p_value < 0.01)
  {
    print("The null hypothesis has been rejected")
  }
  else
  {
    print("Null hypothesis has been accepted.")
  }
}
```

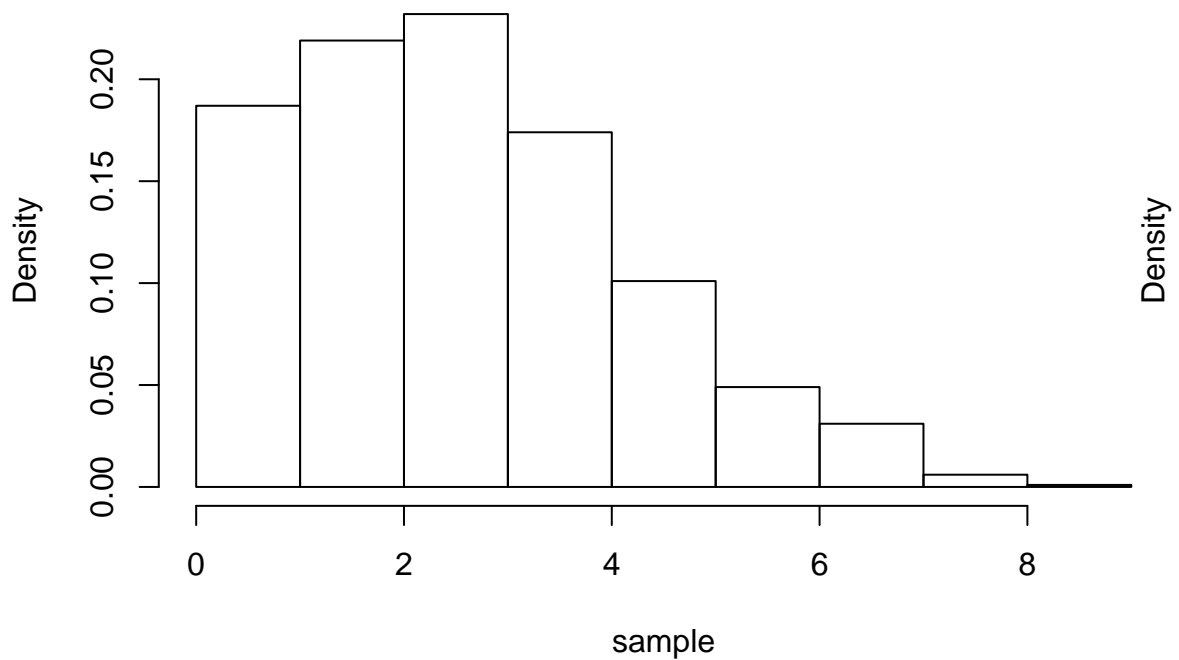
```
for(i in 1:10) {
  sample <- rpois(1000, lambda = i)
```

```
hist(sample, probability = 1)
}
```

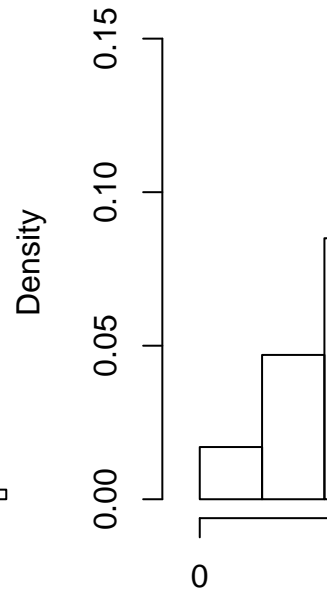
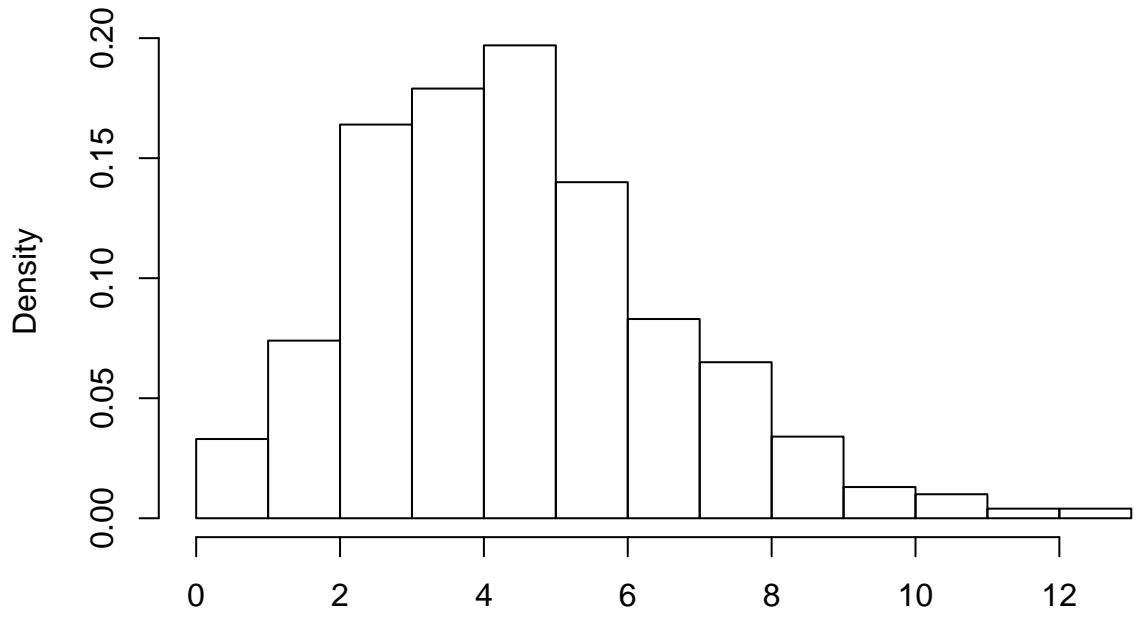
Histogram of sample



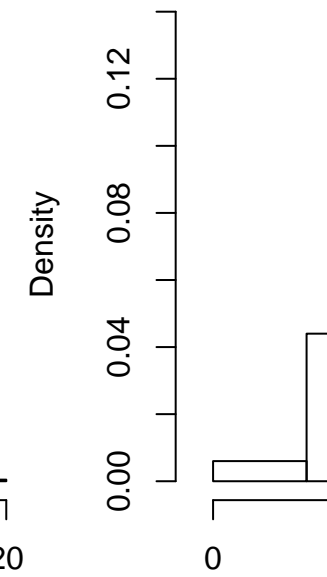
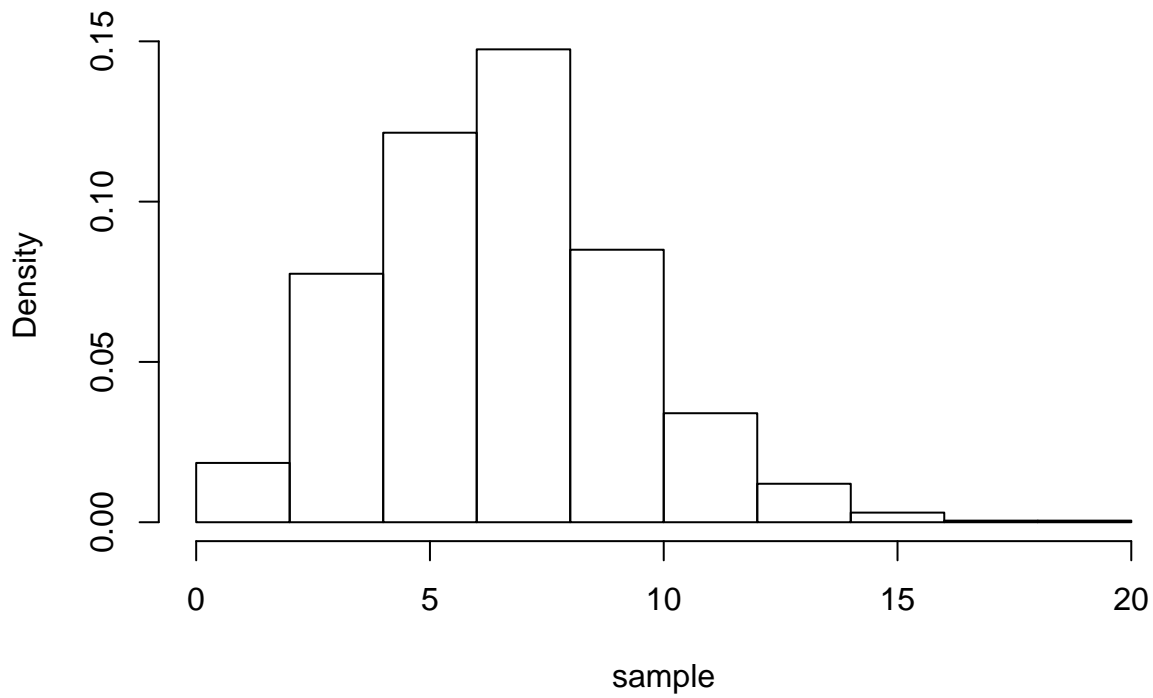
Histogram of sample

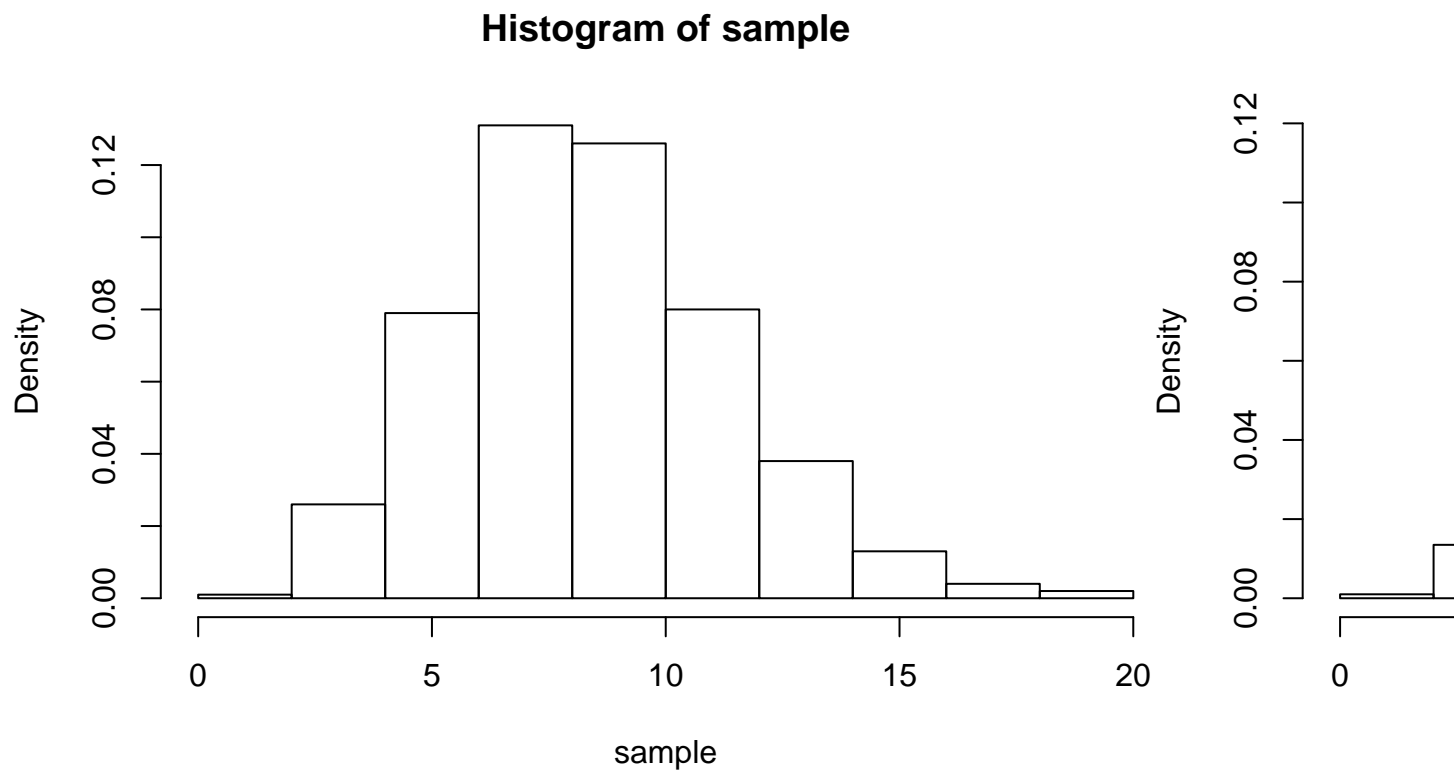


Histogram of sample



Histogram of sample

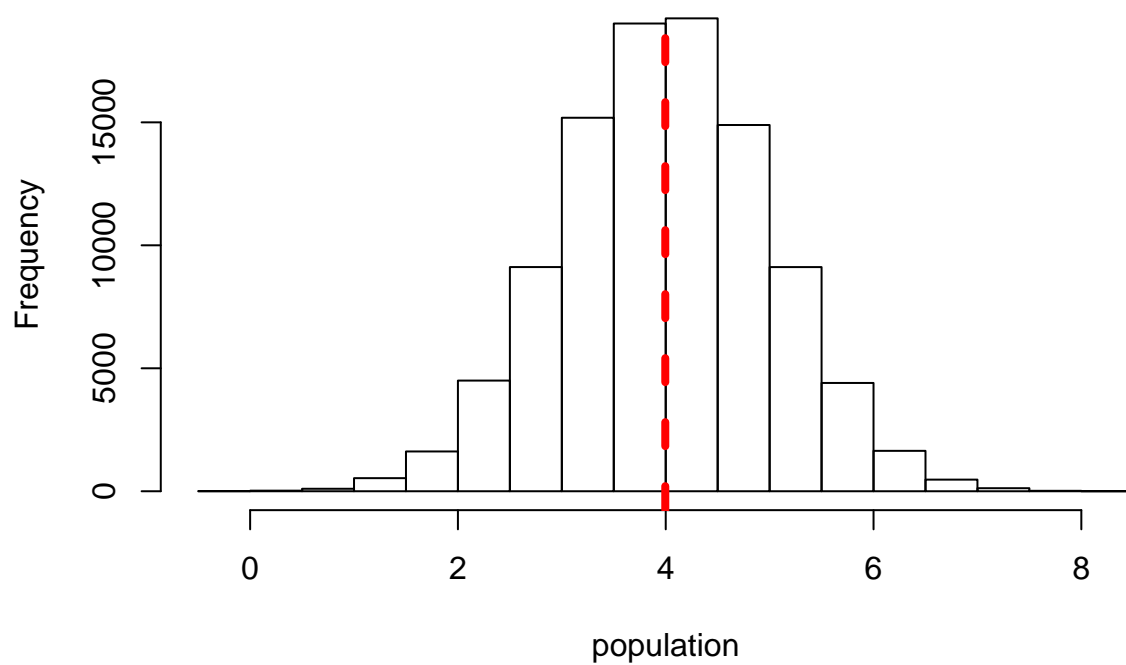




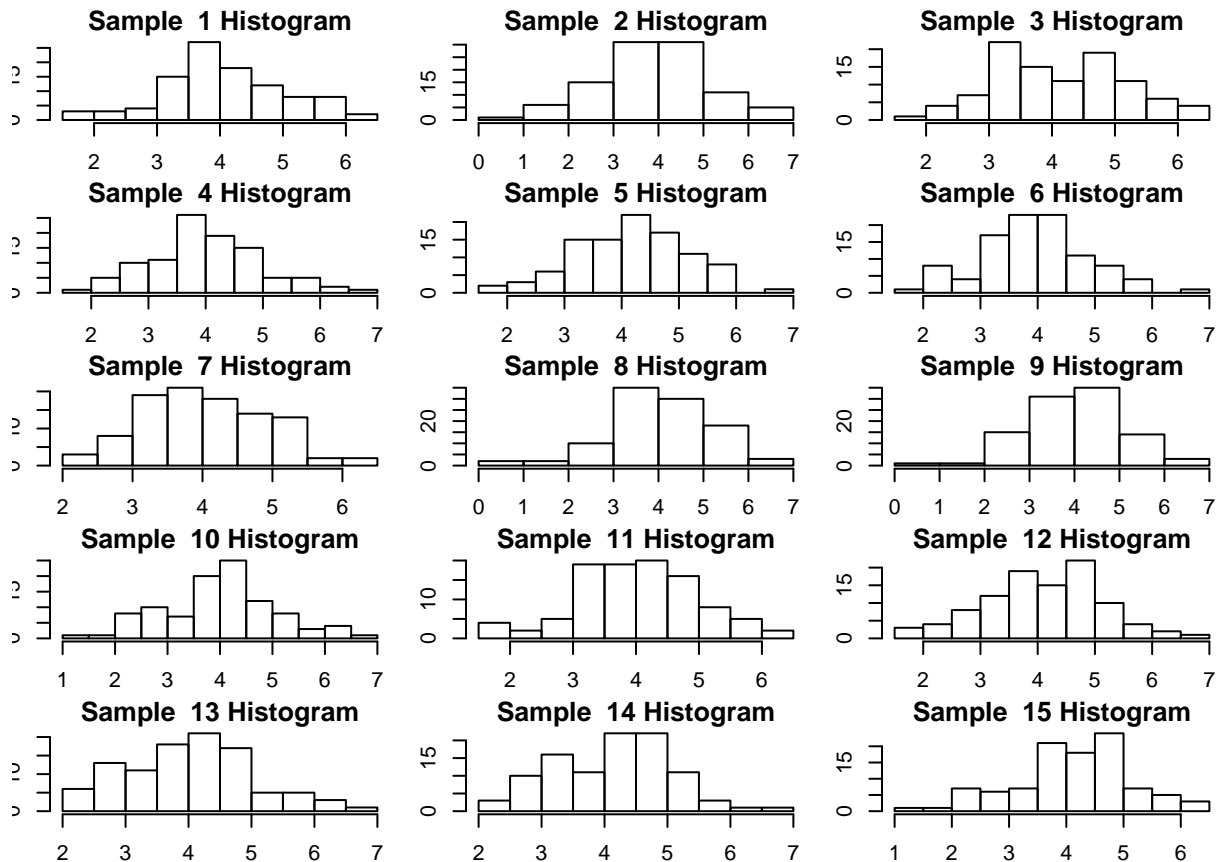
For low number of lambda the diagram is mostly right-skewed but the more lambda increase the more it gets similar to symmetric diagram.

```
population <- rnorm(100000, 4)
hist(population)
abline(v = mean(population), col = "red", lty = 2, lwd = 4)
```

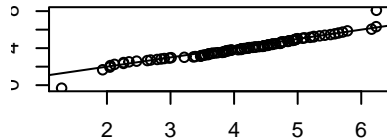
Histogram of population



```
par(mfrow = c(5, 3), mar = c(2, 1.5, 1.5, 1.5))
for(i in 1:15)
{
  new_sample <- sample(population, size = 100)
  hist(new_sample, main = paste("Sample ", i, "Histogram"))
}
```



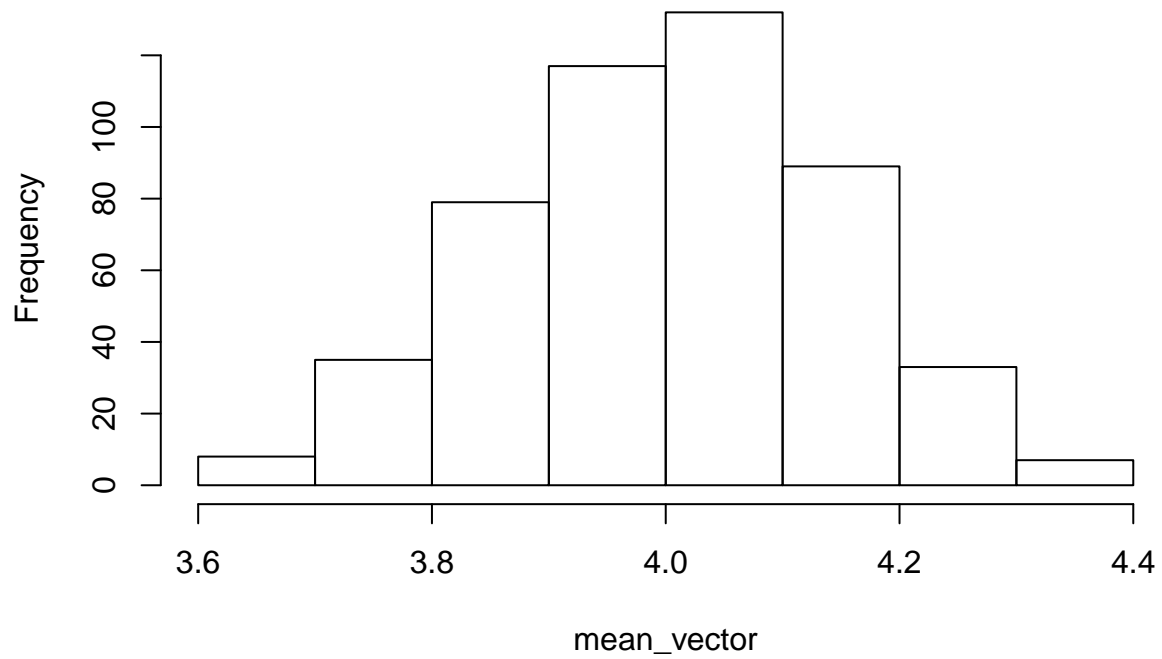
```
qqplot(new_sample, population)
abline(0, 1)
```



As we can observe in the plot data lies mostly in the 45 degree line so it is very close to the original distribution

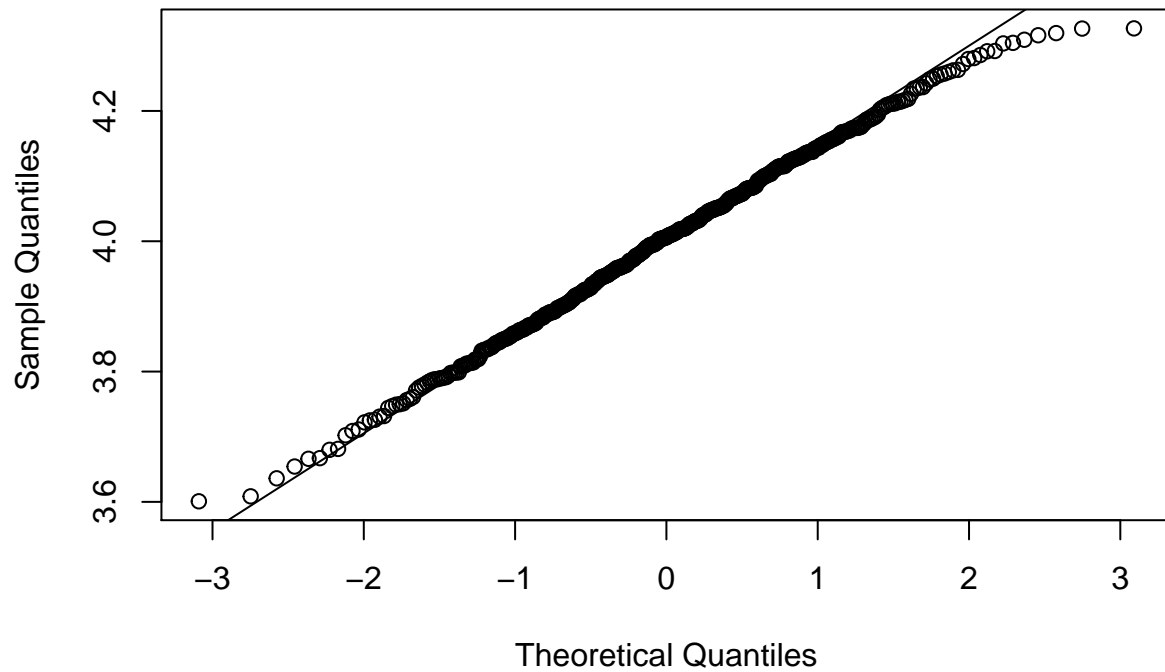
```
mean_vector <- c()
for(i in 1:500)
{
  new_sample <- sample(population, size = 50)
  mean_vector <- c(mean_vector, mean(new_sample))
}
hist(mean_vector)
```

Histogram of mean_vector

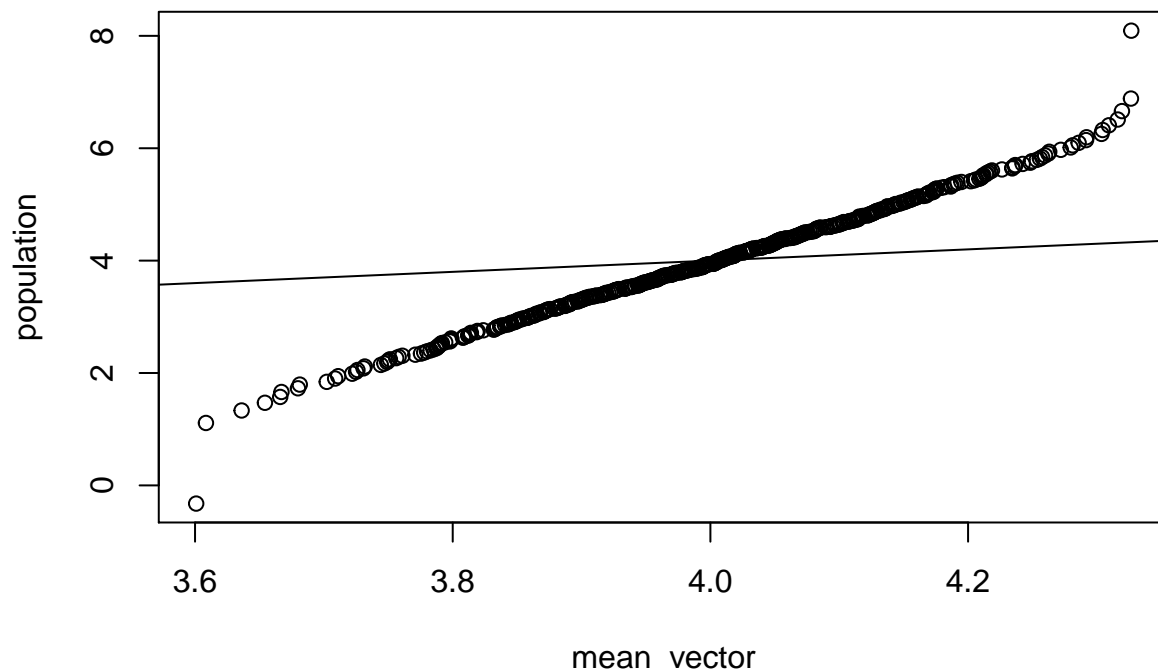


```
qqnorm(mean_vector)
qqline(mean_vector)
```

Normal Q-Q Plot



```
qqplot(mean_vector, population)
abline(0, 1)
```



As we can see in the qqplot the distribution is very similar to normal and this has happened because of the CLT because our sample size is less than 10% of the population and the sample size is at least 30.

If the distribution were skewed we should sample more. But it is less dependent to the distribution.

```
print(paste("The mean is: ", mean(mean_vector)))
```

```
## [1] "The mean is: 4.00178611838704"
```

```
print(paste("The standard deviation is: ", sd(mean_vector)))
```

```
## [1] "The standard deviation is: 0.140020066599173"
```

```
print(paste("Estimation mean and sd are: ", mean(mean_vector), sd(mean_vector) * sqrt(50)))
```

```
## [1] "Estimation mean and sd are: 4.00178611838704 0.990091385944674"
```

```
print(paste("Population statistical points are: ", mean(population), sd(population)))
```

```
## [1] "Population statistical points are: 3.99563809668933 1.00063064925263"
```

```
library(mosaicData)
heights <- Galton$height
z <- -1 * qnorm((0.03)/2)
mean_heights <- mean(heights)
sd_heights <- sd(heights)
sd_heights <- sd_heights / sqrt(50)
count = 0
for(i in 1:10000)
{
  new_sample <- sample(heights, 50)
  mean_new <- mean(new_sample)
  end_interval <- mean_new + z * sd_heights
  start_interval <- mean_new - z * sd_heights
  if(mean_heights <= end_interval && mean_heights >= start_interval)
  {
```



```

    count <- count + 1
  }
}
print((count / 10000) * 100)

```

```
## [1] 97.34
```

The value is very close to 97% and this is because each time the mean will lie in the confidence interval with chance of 97%. Therefore its expectation value would be $(97/100) * \text{number of samples}$.

```

z <- -1 * qnorm((0.1)/2)
mean_heights <- mean(heights)
sd_heights <- sd(heights)
sd_heights <- sd_heights / sqrt(10)
count <- 0
for(i in 1:10000)
{
  new_sample <- sample(heights, 10)
  mean_new <- mean(new_sample)
  end_interval <- mean_new + z * sd_heights
  start_interval <- mean_new - z * sd_heights
  if(mean_heights <= end_interval && mean_heights >= start_interval)
  {
    count <- count + 1
  }
}
print(count / 100)

```

```
## [1] 89.85
```

```

sample_for_graph <- sample(heights, 60)
vector_confident <- seq(0, 1, 0.001)
len_confident <- c()
for(confident in vector_confident)
{
  new_len <- calculate_ci(sample_for_graph, confident)
  len_confident <- c(len_confident, new_len)
}

```

```

## [1] "lower tail is : 66.6666666666667"
## [1] "upper tail is : 66.6666666666667"
## [1] "lower tail is : 66.6645263983337"
## [1] "upper tail is : 66.6688069349996"
## [1] "lower tail is : 66.6623861266388"
## [1] "upper tail is : 66.6709472066945"
## [1] "lower tail is : 66.66024584822"
## [1] "upper tail is : 66.6730874851133"
## [1] "lower tail is : 66.6581055597153"
## [1] "upper tail is : 66.675227773618"
## [1] "lower tail is : 66.6559652577625"
## [1] "upper tail is : 66.6773680755709"
## [1] "lower tail is : 66.6538249389992"
## [1] "upper tail is : 66.6795083943341"
## [1] "lower tail is : 66.651684600063"
## [1] "upper tail is : 66.6816487332703"
## [1] "lower tail is : 66.6495442375913"

```

```
## [1] "upper tail is : 66.6837890957421"  
## [1] "lower tail is : 66.6474038482209"  
## [1] "upper tail is : 66.6859294851124"  
## [1] "lower tail is : 66.6452634285888"  
## [1] "upper tail is : 66.6880699047446"  
## [1] "lower tail is : 66.6431229753312"  
## [1] "upper tail is : 66.6902103580022"  
## [1] "lower tail is : 66.6409824850841"  
## [1] "upper tail is : 66.6923508482492"  
## [1] "lower tail is : 66.6388419544833"  
## [1] "upper tail is : 66.69449137885"  
## [1] "lower tail is : 66.6367013801639"  
## [1] "upper tail is : 66.6966319531694"  
## [1] "lower tail is : 66.6345607587606"  
## [1] "upper tail is : 66.6987725745728"  
## [1] "lower tail is : 66.6324200869075"  
## [1] "upper tail is : 66.7009132464258"  
## [1] "lower tail is : 66.6302793612384"  
## [1] "upper tail is : 66.7030539720949"  
## [1] "lower tail is : 66.6281385783863"  
## [1] "upper tail is : 66.7051947549471"  
## [1] "lower tail is : 66.6259977349834"  
## [1] "upper tail is : 66.7073355983499"  
## [1] "lower tail is : 66.6238568276617"  
## [1] "upper tail is : 66.7094765056717"  
## [1] "lower tail is : 66.6217158530521"  
## [1] "upper tail is : 66.7116174802813"  
## [1] "lower tail is : 66.6195748077849"  
## [1] "upper tail is : 66.7137585255484"  
## [1] "lower tail is : 66.6174336884897"  
## [1] "upper tail is : 66.7158996448437"  
## [1] "lower tail is : 66.615292491795"  
## [1] "upper tail is : 66.7180408415383"  
## [1] "lower tail is : 66.6131512143289"  
## [1] "upper tail is : 66.7201821190044"  
## [1] "lower tail is : 66.6110098527183"  
## [1] "upper tail is : 66.7223234806151"  
## [1] "lower tail is : 66.6088684035891"  
## [1] "upper tail is : 66.7244649297443"  
## [1] "lower tail is : 66.6067268635665"  
## [1] "upper tail is : 66.7266064697669"  
## [1] "lower tail is : 66.6045852292745"  
## [1] "upper tail is : 66.7287481040589"  
## [1] "lower tail is : 66.6024434973361"  
## [1] "upper tail is : 66.7308898359972"  
## [1] "lower tail is : 66.6003016643734"  
## [1] "upper tail is : 66.73303166896"  
## [1] "lower tail is : 66.5981597270071"  
## [1] "upper tail is : 66.7351736063263"  
## [1] "lower tail is : 66.5960176818569"  
## [1] "upper tail is : 66.7373156514765"  
## [1] "lower tail is : 66.5938755255413"  
## [1] "upper tail is : 66.739457807792"  
## [1] "lower tail is : 66.5917332546777"
```

```
## [1] "upper tail is : 66.7416000786557"
## [1] "lower tail is : 66.5895908658819"
## [1] "upper tail is : 66.7437424674514"
## [1] "lower tail is : 66.5874483557688"
## [1] "upper tail is : 66.7458849775645"
## [1] "lower tail is : 66.5853057209517"
## [1] "upper tail is : 66.7480276123817"
## [1] "lower tail is : 66.5831629580425"
## [1] "upper tail is : 66.7501703752908"
## [1] "lower tail is : 66.5810200636519"
## [1] "upper tail is : 66.7523132696815"
## [1] "lower tail is : 66.5788770343889"
## [1] "upper tail is : 66.7544562989444"
## [1] "lower tail is : 66.5767338668613"
## [1] "upper tail is : 66.756599466472"
## [1] "lower tail is : 66.5745905576751"
## [1] "upper tail is : 66.7587427756582"
## [1] "lower tail is : 66.5724471034349"
## [1] "upper tail is : 66.7608862298985"
## [1] "lower tail is : 66.5703035007435"
## [1] "upper tail is : 66.7630298325898"
## [1] "lower tail is : 66.5681597462024"
## [1] "upper tail is : 66.765173587131"
## [1] "lower tail is : 66.566015836411"
## [1] "upper tail is : 66.7673174969223"
## [1] "lower tail is : 66.5638717679674"
## [1] "upper tail is : 66.7694615653659"
## [1] "lower tail is : 66.5617275374676"
## [1] "upper tail is : 66.7716057958657"
## [1] "lower tail is : 66.5595831415061"
## [1] "upper tail is : 66.7737501918273"
## [1] "lower tail is : 66.5574385766753"
## [1] "upper tail is : 66.7758947566581"
## [1] "lower tail is : 66.5552938395658"
## [1] "upper tail is : 66.7780394937676"
## [1] "lower tail is : 66.5531489267664"
## [1] "upper tail is : 66.7801844065669"
## [1] "lower tail is : 66.551003834864"
## [1] "upper tail is : 66.7823294984694"
## [1] "lower tail is : 66.5488585604432"
## [1] "upper tail is : 66.7844747728901"
## [1] "lower tail is : 66.5467131000869"
## [1] "upper tail is : 66.7866202332464"
## [1] "lower tail is : 66.5445674503759"
## [1] "upper tail is : 66.7887658829575"
## [1] "lower tail is : 66.5424216078886"
## [1] "upper tail is : 66.7909117254447"
## [1] "lower tail is : 66.5402755692017"
## [1] "upper tail is : 66.7930577641317"
## [1] "lower tail is : 66.5381293308893"
## [1] "upper tail is : 66.795204002444"
## [1] "lower tail is : 66.5359828895237"
## [1] "upper tail is : 66.7973504438096"
## [1] "lower tail is : 66.5338362416745"
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[1] "upper tail is : 66.7994970916588"
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[1] "upper tail is : 66.8747866926308"
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[1] "lower tail is : 66.4542335292964"
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[1] "lower tail is : 66.4520764670258"
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[1] "upper tail is : 66.8834142710209"
[1] "lower tail is : 66.4477613116032"
[1] "upper tail is : 66.8855720217301"
[1] "lower tail is : 66.4456032113409"
[1] "upper tail is : 66.8877301219925"
[1] "lower tail is : 66.4434447579644"
[1] "upper tail is : 66.8898885753689"
[1] "lower tail is : 66.4412859479088"
[1] "upper tail is : 66.8920473854246"
[1] "lower tail is : 66.4391267776049"
[1] "upper tail is : 66.8942065557285"
[1] "lower tail is : 66.4369672434795"
[1] "upper tail is : 66.8963660898539"
[1] "lower tail is : 66.4348073419553"
[1] "upper tail is : 66.8985259913781"
[1] "lower tail is : 66.4326470694507"
[1] "upper tail is : 66.9006862638826"
[1] "lower tail is : 66.4304864223801"
[1] "upper tail is : 66.9028469109532"
[1] "lower tail is : 66.4283253971535"
[1] "upper tail is : 66.9050079361799"
[1] "lower tail is : 66.4261639901764"
[1] "upper tail is : 66.9071693431569"
[1] "lower tail is : 66.4240021978504"
[1] "upper tail is : 66.9093311354829"
[1] "lower tail is : 66.4218400165723"
[1] "upper tail is : 66.9114933167611"
[1] "lower tail is : 66.4196774427346"
[1] "upper tail is : 66.9136558905988"
[1] "lower tail is : 66.4175144727253"

```
## [1] "upper tail is : 66.915818860608"  
## [1] "lower tail is : 66.4153511029281"  
## [1] "upper tail is : 66.9179822304053"  
## [1] "lower tail is : 66.4131873297217"  
## [1] "upper tail is : 66.9201460036117"  
## [1] "lower tail is : 66.4110231494805"  
## [1] "upper tail is : 66.9223101838529"  
## [1] "lower tail is : 66.4088585585741"  
## [1] "upper tail is : 66.9244747747593"  
## [1] "lower tail is : 66.4066935533674"  
## [1] "upper tail is : 66.9266397799659"  
## [1] "lower tail is : 66.4045281302208"  
## [1] "upper tail is : 66.9288052031125"  
## [1] "lower tail is : 66.4023622854895"  
## [1] "upper tail is : 66.9309710478439"  
## [1] "lower tail is : 66.4001960155241"  
## [1] "upper tail is : 66.9331373178093"  
## [1] "lower tail is : 66.3980293166702"  
## [1] "upper tail is : 66.9353040166631"  
## [1] "lower tail is : 66.3958621852686"  
## [1] "upper tail is : 66.9374711480647"  
## [1] "lower tail is : 66.3936946176551"  
## [1] "upper tail is : 66.9396387156783"  
## [1] "lower tail is : 66.3915266101603"  
## [1] "upper tail is : 66.941806723173"  
## [1] "lower tail is : 66.3893581591099"  
## [1] "upper tail is : 66.9439751742234"  
## [1] "lower tail is : 66.3871892608245"  
## [1] "upper tail is : 66.9461440725088"  
## [1] "lower tail is : 66.3850199116194"  
## [1] "upper tail is : 66.9483134217139"  
## [1] "lower tail is : 66.3828501078048"  
## [1] "upper tail is : 66.9504832255285"  
## [1] "lower tail is : 66.3806798456856"  
## [1] "upper tail is : 66.9526534876477"  
## [1] "lower tail is : 66.3785091215614"  
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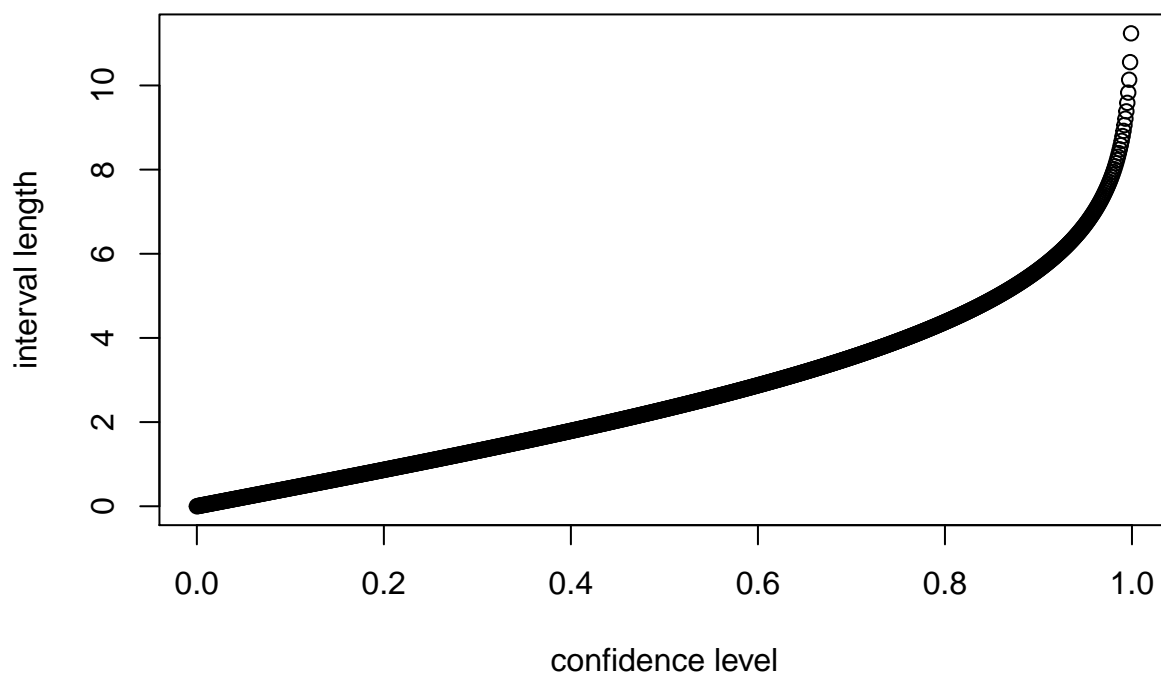
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## [1] "lower tail is : 63.1595071480525"
## [1] "upper tail is : 70.1738261852809"
## [1] "lower tail is : 63.1416823497478"
## [1] "upper tail is : 70.1916509835855"
## [1] "lower tail is : 63.1234650153847"
## [1] "upper tail is : 70.2098683179486"
## [1] "lower tail is : 63.1048352974066"
## [1] "upper tail is : 70.2284980359267"
## [1] "lower tail is : 63.0857717700386"
## [1] "upper tail is : 70.2475615632947"
## [1] "lower tail is : 63.066251255602"
## [1] "upper tail is : 70.2670820777313"
## [1] "lower tail is : 63.0462486261107"
## [1] "upper tail is : 70.2870847072226"
## [1] "lower tail is : 63.0257365757872"
## [1] "upper tail is : 70.3075967575461"
## [1] "lower tail is : 63.0046853592075"
## [1] "upper tail is : 70.3286479741258"
## [1] "lower tail is : 62.9830624886228"
## [1] "upper tail is : 70.3502708447105"
## [1] "lower tail is : 62.9608323825441"
## [1] "upper tail is : 70.3725009507892"
## [1] "lower tail is : 62.93795559558193"
## [1] "upper tail is : 70.3953773775141"
## [1] "lower tail is : 62.9143901390618"
## [1] "upper tail is : 70.4189431942716"
## [1] "lower tail is : 62.8900873122373"
## [1] "upper tail is : 70.443246021096"
## [1] "lower tail is : 62.8649946332487"
## [1] "upper tail is : 70.4683387000847"
## [1] "lower tail is : 62.8390532371608"
## [1] "upper tail is : 70.4942800961726"
## [1] "lower tail is : 62.8121972748329"
## [1] "upper tail is : 70.5211360585004"
## [1] "lower tail is : 62.7843527505277"
## [1] "upper tail is : 70.5489805828057"
## [1] "lower tail is : 62.7554361056352"
## [1] "upper tail is : 70.5778972276981"
## [1] "lower tail is : 62.7253524786386"
## [1] "upper tail is : 70.6079808546948"
## [1] "lower tail is : 62.6939935478577"
```

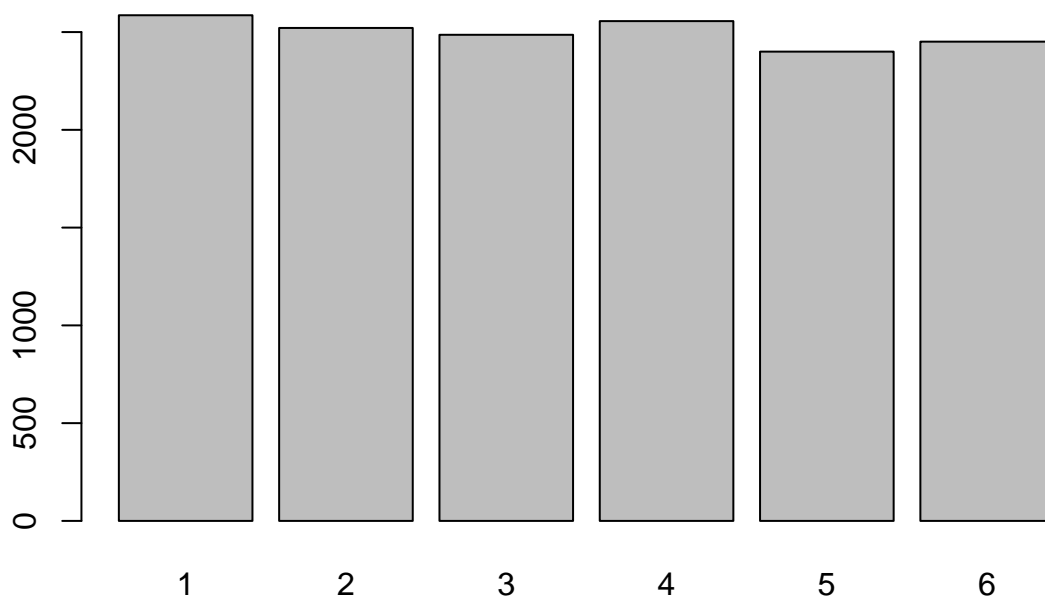
```
## [1] "upper tail is : 70.6393397854756"
## [1] "lower tail is : 62.6612348303385"
## [1] "upper tail is : 70.6720985029948"
## [1] "lower tail is : 62.6269322628705"
## [1] "upper tail is : 70.7064010704629"
## [1] "lower tail is : 62.5909178222768"
## [1] "upper tail is : 70.7424155110565"
## [1] "lower tail is : 62.5529938402035"
## [1] "upper tail is : 70.7803394931298"
## [1] "lower tail is : 62.512925513583"
## [1] "upper tail is : 70.8204078197504"
## [1] "lower tail is : 62.4704308736311"
## [1] "upper tail is : 70.8629024597023"
## [1] "lower tail is : 62.4251670978682"
## [1] "upper tail is : 70.9081662354652"
## [1] "lower tail is : 62.3767114310369"
## [1] "upper tail is : 70.9566219022964"
## [1] "lower tail is : 62.3245339350267"
## [1] "upper tail is : 71.0087993983067"
## [1] "lower tail is : 62.2679574508027"
## [1] "upper tail is : 71.0653758825307"
## [1] "lower tail is : 62.2060967804825"
## [1] "upper tail is : 71.1272365528508"
## [1] "lower tail is : 62.1377625622443"
## [1] "upper tail is : 71.1955707710891"
## [1] "lower tail is : 62.0613018283482"
## [1] "upper tail is : 71.2720315049852"
## [1] "lower tail is : 61.9743171826835"
## [1] "upper tail is : 71.3590161506499"
## [1] "lower tail is : 61.873132681692"
## [1] "upper tail is : 71.4602006516414"
## [1] "lower tail is : 61.7516683983173"
## [1] "upper tail is : 71.5816649350161"
## [1] "lower tail is : 61.5987003443314"
## [1] "upper tail is : 71.7346329890019"
## [1] "lower tail is : 61.3895183301783"
## [1] "upper tail is : 71.943815003155"
## [1] "lower tail is : 61.0474782216411"
## [1] "upper tail is : 72.2858551116923"
## [1] "lower tail is : -Inf"
## [1] "upper tail is : Inf"
```

```
plot(vector_confident, len_confident, main = "Diagram confidence interval length based on its confidence")
```

Diagram confidence interval length based on its confidence level



```
outcome_dice <- c(1, 2, 3, 4, 5, 6)
vector_simulate <- sample(outcome_dice, 15000, replace = TRUE)
table_simulate <- table(vector_simulate)
barplot(table_simulate)
```



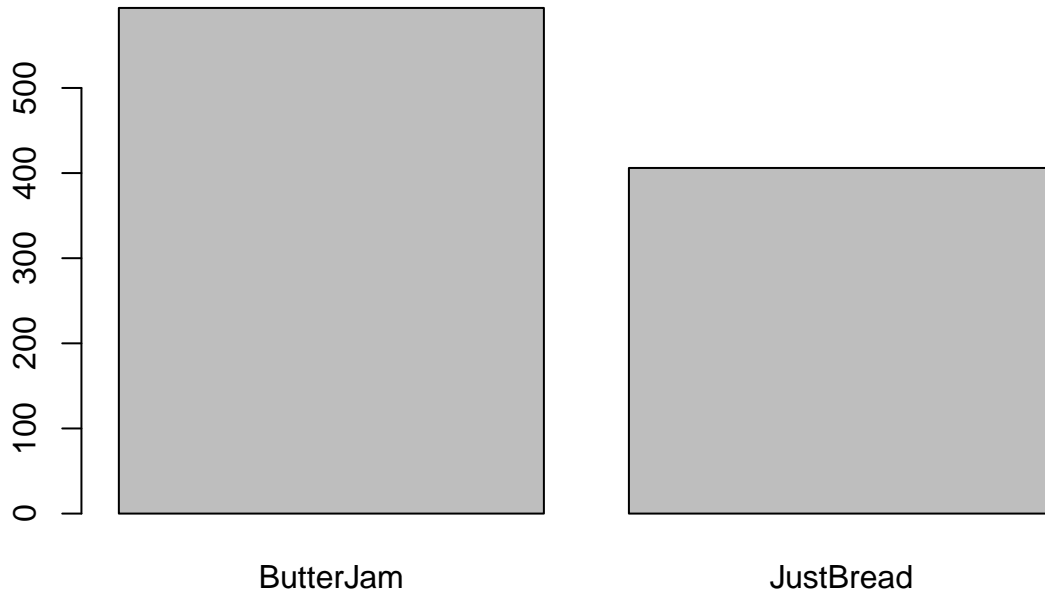
```
count <- c(table_simulate)
count <- count / sum(count)
print(count)
```

```
##      1      2      3      4      5      6
## 0.1724000 0.1680667 0.1657333 0.1704000 0.1600000 0.1634000
```

```

outcomes <- c("ButterJam", "JustBread")
sample_toast <- sample(outcomes, 1000, replace = TRUE, prob = c(0.6, 0.4))
table_toast <- table(sample_toast)
barplot(table_toast)

```



```
print(table_toast)
```

```

## sample_toast
## ButterJam JustBread
##      594      406

dice <- c(1, 2, 3, 4, 5, 6)
d1 <- sample(dice, 100000, replace = TRUE)
d2 <- sample(dice, 100000, replace = TRUE)
sum_ok <- (d1 + d2) > 8
tb_dice <- table(sum_ok)
vec_sum <- c(tb_dice)
vec_sum <- vec_sum / sum(vec_sum)
print(vec_sum)

```

```

## FALSE TRUE
## 0.72415 0.27585

```

The value is equal to the theoretical one which is $10/36$.

```
library("mosaicData")
```

```
Weather$city
```

```

##      [1] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##      [7] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [13] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [19] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [25] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [31] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [37] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"
##     [43] "Auckland" "Auckland" "Auckland" "Auckland" "Auckland" "Auckland"

```


[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```
## [3613] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3619] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3625] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3631] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3637] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3643] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3649] "San Diego" "San Diego" "San Diego" "San Diego" "San Diego" "San Diego"
## [3655] "San Diego"
```

```
Beijing_city <- Weather[Weather$city == 'Beijing', ]
```

```
sample_avg_humidity <- Beijing_city$avg_humidity
t.test(sample_avg_humidity - 50, alternative = "two.sided", conf.level = 0.95)
```

```
##
## One Sample t-test
##
## data: sample_avg_humidity - 50
## t = 4.0438, df = 730, p-value = 5.818e-05
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
## 1.561839 4.509296
## sample estimates:
## mean of x
## 3.035568
```

The p-value is less than significance level(0.01) thus we could interpret that the null hypothesis is wrong and the humidity is not 50%.

Practically it is hard to reject it and this is because the practical significance is different from the scientific significance level.

```
library("MASS")
t.test(shrimp - 33, alternative = "less", conf.level = 0.95)
```

```
##
## One Sample t-test
##
## data: shrimp - 33
## t = -2.7746, df = 17, p-value = 0.00649
## alternative hypothesis: true mean is less than 0
## 95 percent confidence interval:
## -Inf -0.4496989
## sample estimates:
## mean of x
## -1.205556
```

Yes because p-value is less than 0.01 Therefore the alternative hypothesis is correct which is less than 33.

```
two_tail_z_dist_mean_hyp_test(Beijing_city$avg_humidity, 50, 0.05)
```

```
## [1] "P value is: 5.81823951856957e-05"
## [1] "The null hypothesis has been rejected"
```

```
two_tail_z_dist_mean_hyp_test(shrimp, 33, 0.05)
```

```
## [1] "Warning: the data size is not enough for satisfying the CLT condition"
## [1] "P value is: 0.0129806490115911"
```

```
## [1] "Null hypothesis has been accepted."
```