MA213 Basic Statistics and Probability - Lab4 (Hypothesis Testing Using Simulation)

Lab 4: Simulation and Probability guide 2

Hypothesis Testing Using Simulation

Malaria vaccine Example.

The data shows effectiveness of malaria vaccine named PfSPZ.

In the study, volunteer participants were randomly assigned to one of two groups: 14 individuals received the experimental vaccine, while 6 received a placebo. Nineteen weeks later, all 20 participants were deliberately exposed to a drug-sensitive strain of the malaria virus. The decision to use a drug-sensitive strain was driven by ethical reasons, ensuring that any resulting infections could be effectively treated. The table below shows that 9 out of the 14 patients who received the treatment did not display any signs of infection, whereas all 6 patients in the control group showed some initial symptoms of infection.

```
          Infection   no infection    Total
vaccine   5           9               14
placebo   6           0               6
Total     11          9               20
```

What are the null hypothesis and alternative hypothesis in this study?

Based on the data, `5/14 = 35.7%` of the patients who received the vaccine showed signs of infection, while `6/6 = 100%` of the patients who received a placebo exhibited signs of infection.

H_0 : **Independence model**. The variables treatment and outcome are independent. They have no relationship, and the observed difference between the proportion of patients who developed an infection in the two groups, 64.3%, was due to chance.

H_a : **Alternative model**. The variables are not independent. The difference in infection rates of 64.3% was not due to chance, and vaccine affected the rate of infection.

How to simulate them?

We take 11 “Infection” and 9 “no infection” as the total data.

```
data <- c(rep("Infection", 11), rep("no infection", 9))

data
```

```
##  [1] "Infection"    "Infection"    "Infection"    "Infection"    "Infection"
##  [6] "Infection"    "Infection"    "Infection"    "Infection"    "Infection"
## [11] "Infection"    "no infection" "no infection" "no infection" "no infection"
## [16] "no infection" "no infection" "no infection" "no infection" "no infection"
```

Randomly take 6 of them as “placebo” and 14 of them as “vaccine”.

```
index <- sample(1:length(data), 6) # this is where we allocate patients regardless of cause of deaths (
```

```r
placebo <- data[index]
vaccine <- data[-index]

placebo
```

```
## [1] "Infection"    "no infection" "Infection"    "no infection" "Infection"
## [6] "Infection"
```

```r
vaccine
```

```
##  [1] "Infection"    "Infection"    "Infection"    "Infection"    "Infection"
##  [6] "Infection"    "Infection"    "no infection" "no infection" "no infection"
## [11] "no infection" "no infection" "no infection" "no infection"
```

Getting the simulated contingency table

```r
group <- c(rep("placebo", length(placebo)), rep("vaccine", length(vaccine)))
outcome <- c(placebo, vaccine)
df <- data.frame(Group = group, Outcome = outcome)
df_table <- table(df)
df_table
```

```
##          Outcome
## Group     Infection no infection
##   placebo         4            2
##   vaccine         7            7
```

Get the ratio difference

```r
ratio1 = df_table[3] / 6
ratio2 = df_table[4] / 14
ratio2-ratio1
```

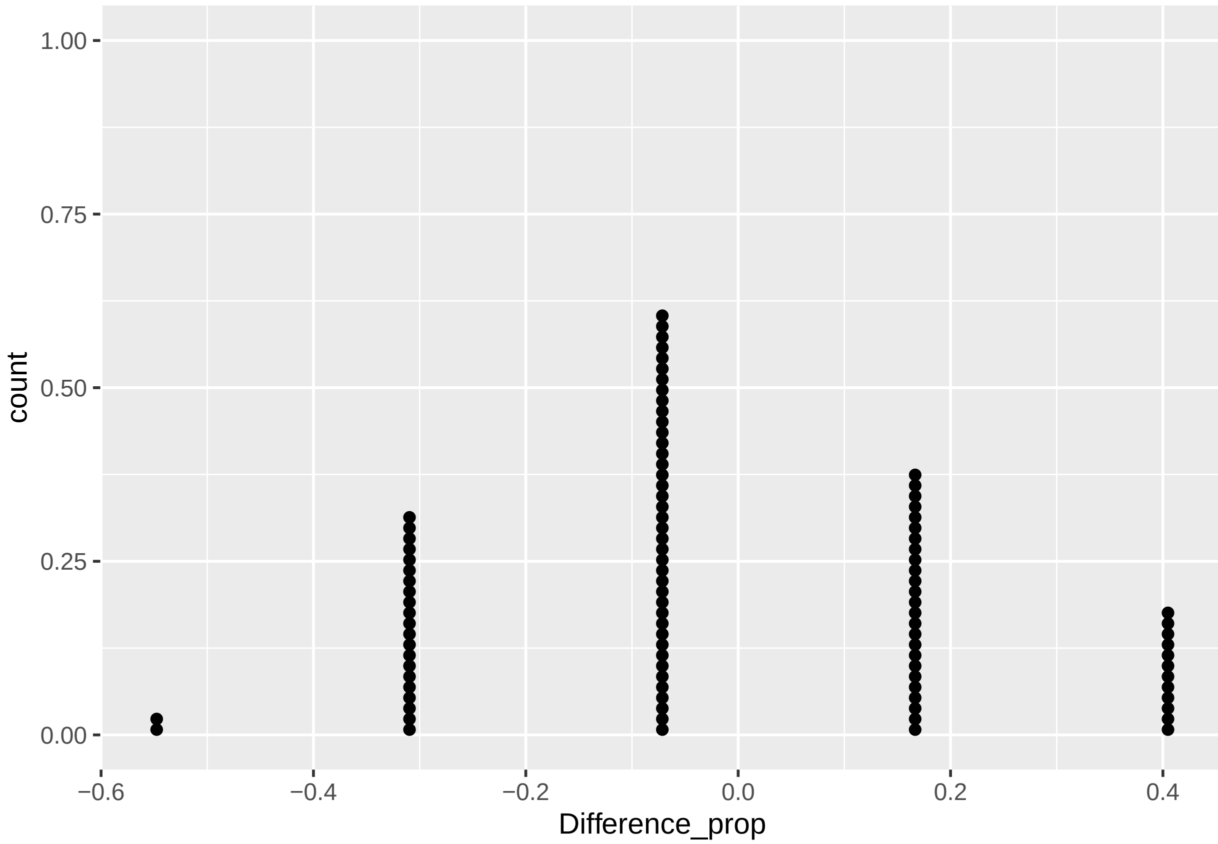
```
## [1] 0.1666667
```

Simulate them 100 times

```r
sim_function<-function(){
  index <- sample(1:20, 6)
  placebo <- data[index]
    vaccine <- data[-index]
  group <- c(rep("placebo", length(placebo)), rep("vaccine", length(vaccine)))
outcome <- c(placebo, vaccine)
df <- data.frame(Group = group, Outcome = outcome)

  df_table <- table(df)
  ratio1 = df_table[3] / 6
  ratio2 = df_table[4] / 14

  out <- ratio2-ratio1


  return(out)
}

sim_function()
```

```
## [1] -0.3095238
```

```r
library(ggplot2)
rates <- rep(0,100)

for (i in 1:100){
  rates[i] <- sim_function()
}
sim_df <- data.frame(Difference_prop=rates)
ggplot(data=sim_df, aes(x=Difference_prop)) + geom_dotplot(binwidth=1/100)
```



Based on the simulation result, we conclude the evidence is statistically significant to reject H_0 and conclude that the vaccine was useful.