

Midterm

Shabir Gazzaly

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R Markdown

—————Problem 1 — (total 8 pt)—————

Question 1:

Null hypothesis- Infection rate with Omicron variant will be the same in Pfizer vaccinated and non vaccinated participants.(Fourth dose of Pfizer vaccine doesn't protect against infection with the omicron variant)

Alternative hypothesis- Infection rate with Omicron variant will be lower in Pfizer vaccinated participants than non vaccinated participants.(Fourth dose of Pfizer vaccine protects against infection with the omicron variant)

Question 2: Statistic will be the difference between estimated number of infected participants in the vaccinated group under null hypothesis and the observed number of infected participants. Therefore, if the infection rate is lower than estimation(under null hypothesis), statistic will be positive.

Estimated infection rate under null hypothesis:

```
80 / 308
```

```
## [1] 0.2597403
```

Can be rounded off to 0.26.

Estimated number of infected participants in the vaccinated group under null hypothesis:

```
0.26*154
```

```
## [1] 40.04
```

```
statistic<-function(x){40.04-x}
```

Question 3:

Generating a null distribution:

```
nulld<-replicate(100000,statistic(rbinom(1,154,0.26)))
```

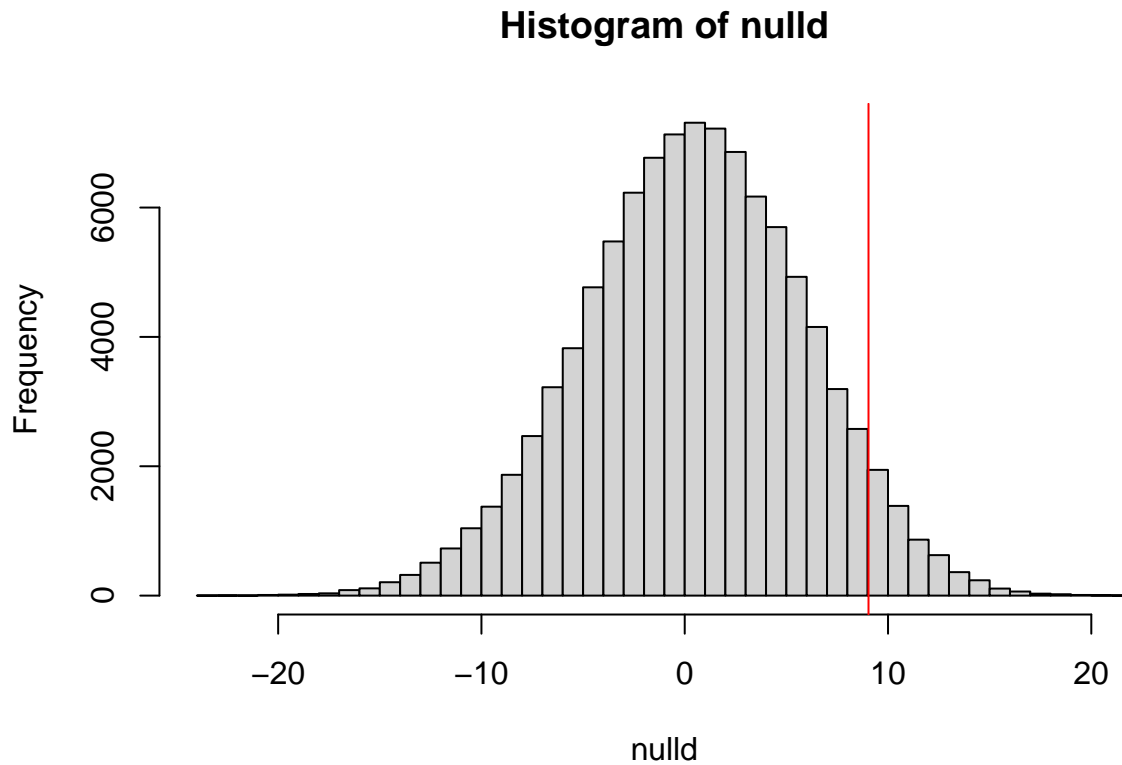
We will use a level of 5%.

Finding threshold:

```
quantile(nulld,0.95)
```

```
## 95%  
## 9.04
```

```
hist(nulld,breaks=50)  
abline(v=9.04,col="red")
```



Question 4:

Statistic of observed value:

```
statistic(28)
```

```
## [1] 12.04
```

Observed statistic is greater than threshold ($12.04 > 9.04$), therefore, we can reject the null hypothesis and conclude that the infection rate is lower in Pfizer vaccinated participants compared to non vaccinated participants, and the fourth dose of Pfizer protects against the omicron variant.

Question 5:

p-value of the test:

```
mean(nulld>=12.04)
```

```
## [1] 0.01466
```

Question 6:

VE is the vaccination efficacy (in %), where “v” is the infection rate in vaccinated participants and “uv” is the infection rate in non vaccinated participants.

```
VE<-function(v,uv){(uv-v)*100/uv}
```

```
v<-28/154
```

```
uv<-80/308
```

```
VE(v,uv)
```

```
## [1] 30
```

efficacy is 30%.

at 50% efficacy, infection rate in vaccinated participants would be $0.26/2 = 0.13$

Null hypothesis: Vaccination efficacy of Pfizer would be 50% (or less)

Alternative hypothesis: Vaccination efficacy of Pfizer would be greater than 50%

Null distribution:

```
null_VE=c()  
nullv=rbinom(100000,154,0.13)/154  
for (i in nullv){null_VE=c(null_VE,VE(i,uv))}
```

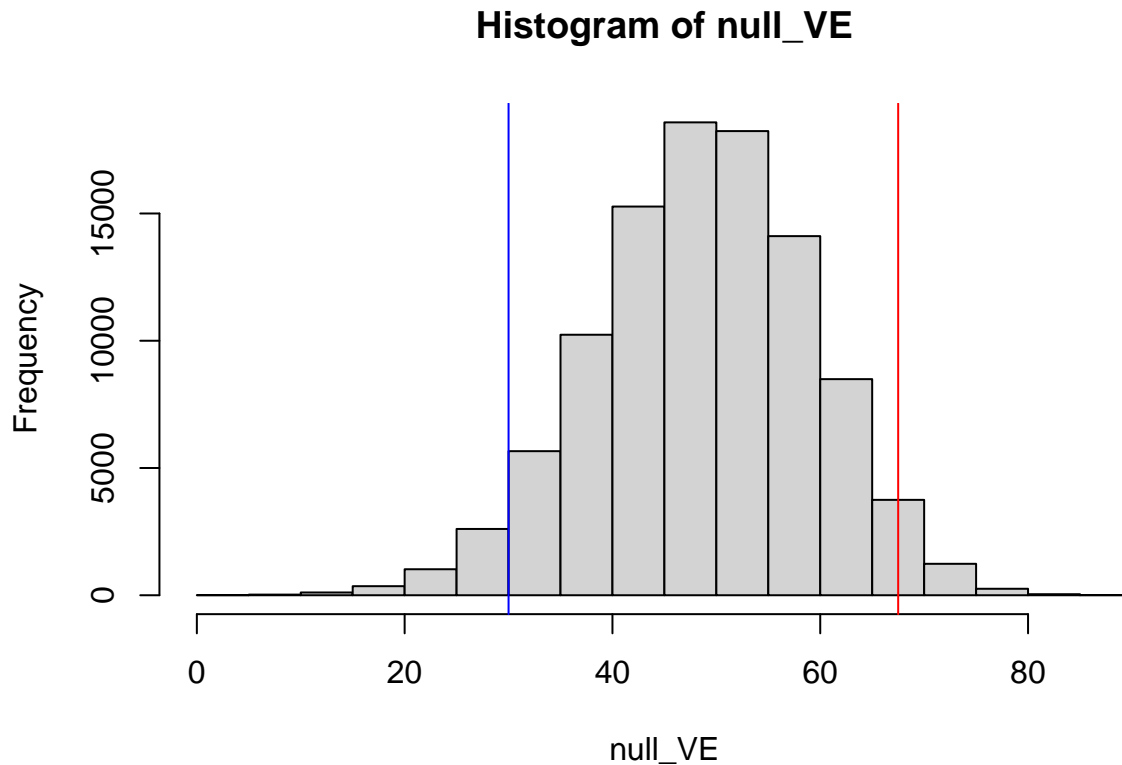
threshold to reject null hypothesis:

```
quantile(null_VE,0.95)
```

```
## 95%
```

```
## 67.5
```

```
hist(null_VE,breaks=30)  
abline(v=quantile(null_VE,0.95),col="red")  
abline(v=30,col="blue")
```



Red line shows the threshold and blue line shows the observed efficacy.

The observed vaccination efficacy is less than threshold ($30 < 67.5$).

p-value:

```
mean(null_VE >= 30)
```

```
## [1] 0.95877
```

Based on the analysis, we can conclude that the Pfizer vaccination efficacy is less than 50%. Although the fourth dose of Pfizer protects against the infection with omicron variant, it does not significantly reduce the risk of getting infected (Efficacy needs to be greater than 50%).

—————Problem 2 — (total 8 pt)—————

Question 1:

Null hypothesis- Infection rate with Omicron variant will be the same in Moderna vaccinated and non vaccinated participants.(Fourth dose of Moderna vaccine doesn't protect against infection with the omicron variant)

Alternative hypothesis- Infection rate with Omicron variant will be lower in Moderna vaccinated participants than non vaccinated participants.(Fourth dose of Moderna vaccine protects against infection with the omicron variant)

Question 2:

Statistic will be the difference between estimated number of infected participants in the vaccinated group under null hypothesis and the observed number of infected participants. Therefore, if the infection rate is lower than estimation(under null hypothesis), statistic will be positive.

Estimated infection rate under null hypothesis:

```
62/ 240
```

```
## [1] 0.2583333
```

Can be rounded off to 0.258.

Estimated number of infected participants in the vaccinated group under null hypothesis:

```
0.258*120
```

```
## [1] 30.96
```

```
statistic<-function(x){30.96-x}
```

Question 3:

Generating a null distribution:

```
nulld<-replicate(100000,statistic(rbinom(1,120,0.258)))
```

We will use a level of 5%.

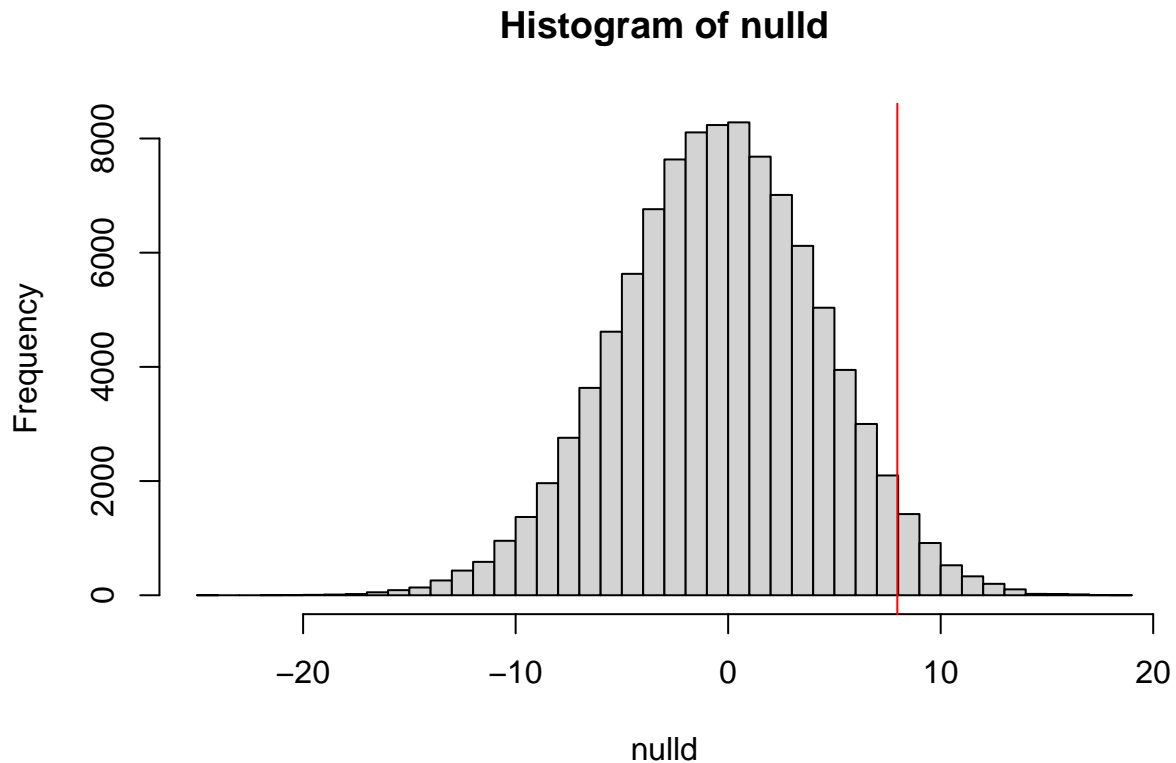
Finding threshold:

```
quantile(nulld,0.95)
```

```
## 95%
```

```
## 7.96
```

```
hist(nulld,breaks=50)  
abline(v=7.96,col="red")
```



Question 4:

Statistic of observed value:

```
statistic(25)
```

```
## [1] 5.96
```

Observed statistic is less than threshold ($5.96 < 7.96$), therefore, we accept the null hypothesis and conclude that the infection rate is similar in Moderna vaccinated participants and non vaccinated participants, and the fourth dose of Moderna doesn't protect against the omicron variant.

Question 5:

p-value of the test:

```
mean(nulld >= 5.96)
```

```
## [1] 0.12606
```

Question 6:

VE is the vaccination efficacy (in %), where “v” is the infection rate in vaccinated participants and “uv” is the infection rate in non vaccinated participants.

```
VE<-function(v,uv){(uv-v)*100/uv}
```

```
v<-25/120  
uv<-62/240
```

```
VE(v,uv)
```

```
## [1] 19.35484
```

efficacy is 19.35%.

at 50% efficacy, infection rate in vaccinated participants would be $0.258/2 = 0.129$

Null hypothesis: Vaccination efficacy of Moderna would be 50% (or less)

Alternative hypothesis: Vaccination efficacy of Moderna would be greater than 50%

Null distribution:

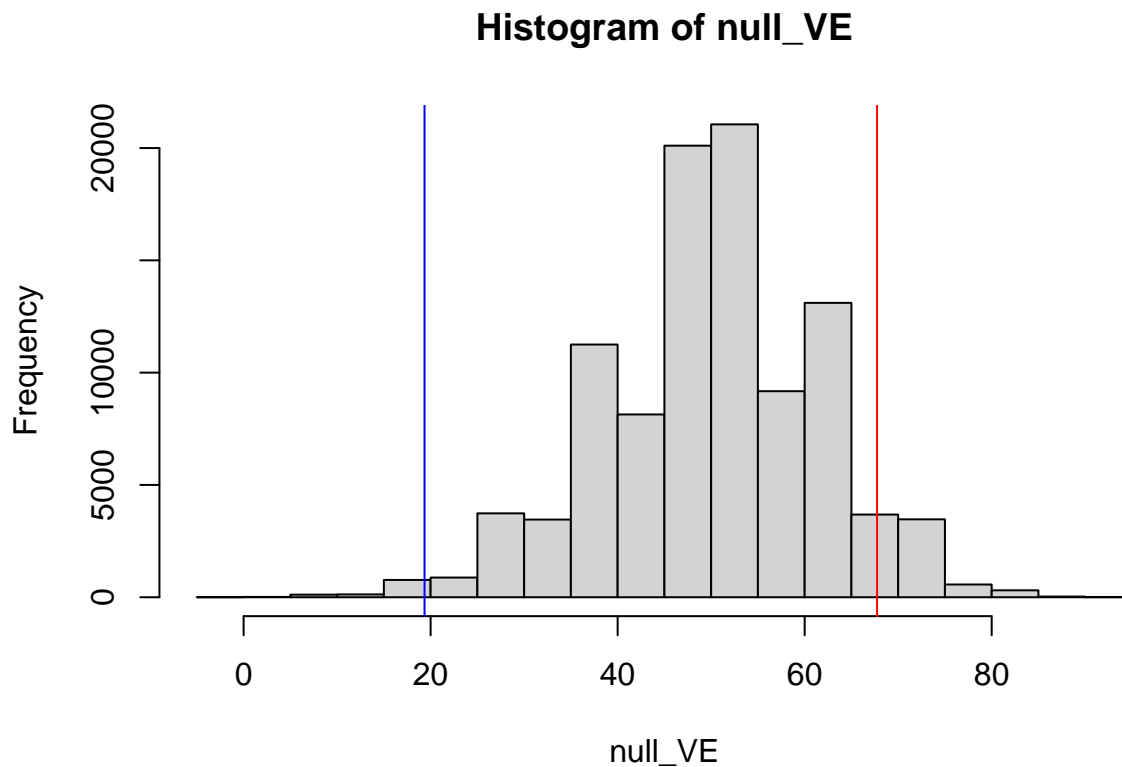
```
null_VE=c()  
nullv=rbinom(100000,120,0.129)/120  
for (i in nullv){null_VE=c(null_VE,VE(i,uv))}
```

threshold to reject null hypothesis:

```
quantile(null_VE,0.95)
```

```
##      95%  
## 67.74194
```

```
hist(null_VE,breaks=30)  
abline(v=quantile(null_VE,0.95),col="red")  
abline(v=19.35,col="blue")
```



Red line shows the threshold and blue line shows the observed efficacy.

The observed vaccination efficacy is less than threshold ($19.35 < 67.74$).

p-value:

```
mean(null_VE >= 19.35)
```

```
## [1] 0.99466
```

Based on the analysis, we can conclude that the Moderna vaccination efficacy is less than 50%. The fourth dose of Moderna doesn't protect against the infection with omicron variant, and it does not significantly reduce the risk of getting infected (Efficacy needs to be greater than 50%).