```
library(openxlsx)

FEV <- read.csv("fev.csv", header=TRUE)
hospital <- c(rep("John.Hopkins", 21), rep("Rancho.Los.Amigos", 16), rep("St.Louis", 23))
fev <- c(FEV[1:21,1], FEV[1:16,2], FEV[1:23,3])

FEV.df <- data.frame(hospital, fev)


fev.anova <- aov(fev ~ hospital, data = FEV.df)

> summary(fev.anova)
            Df  Sum Sq Mean Sq  F value Pr(>F)
hospital     2   1.587  0.7935    3.126   0.0515 .
Residuals   57  14.468  0.2538
---
  Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1



# manual calculation of F statistic
ni <- c(21, 16, 23)
ybari <- c(mean(FEV[1:21,1]), mean(FEV[1:16,2]), mean(FEV[1:23,3]))
si <- c(sd(FEV[1:21,1]), sd(FEV[1:16,2]), sd(FEV[1:23,3]))

SSE <- sum((ni-1)*si ^ 2)

# calculate the grand mean
ybar <- sum(ybari*ni)/sum(ni)

SStr <- sum(ni * (ybari-ybar)^2)

MSE <- SSE/(sum(ni)-length(ni))
MSTr <- SStr/(length(ni)-1)


# calculate F statistic
F <- MSTr/MSE

# this gives F = 3.126004
```