Introduction to Anova (Assignment - 2)

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5/12/2020

Q1) Espresso Data

```
#Variables
1) Brewing method (1, 2 and 3) - categorical method
2) amount fo Creme produced

Hypothesis:
H0: thier is significant diffence in creame production from three different
Brewing methods
H1: Diffrence is seen in production of creme from method to method

Summary:
the main reson of this assignment is to work and understand Anova where I
considered the Espresso Creme production data between three different brewing
methods. I have formated data of categorical variable with method levels.
Even though the data appears nearly normal on density normality plot, I have
noticed a small skewness in the graph. From agostino test (skew = 0.54679, p-
value = 0.1842) as the skewness is not equal to zero, so it can proved that
the data has skewness and p-value is greater than the 0.05 which clarifys
that the data significantly normal and supports the null hypothesis, which
the analaysis is not that clear. The normal curve of the cereme shows the
data is not normal, even though if we consider the data is normal. So for the
further analysis I have conducted the shapiro normality test (W = 0.92201, p-
value = 0.04414) where p-value is less than the 0.05 which says the means of
the group is not equal so it supports the alernative hypothesis. from the
bartlett test (Bartlett's K-squared = 0.96331, df = 2, p-value = 0.6178) the
p-value is greater than 0.05, that defines us that their is no much
difference in variance between group variables. from Anova test if we
consider (F value = 28.41 Pr(>F) =  4.7e-07 ***) the f value has got the
higher values and p-values is less than the 0.05, as most of the tests
support that their is a sifficant difference in creme produciton.
```

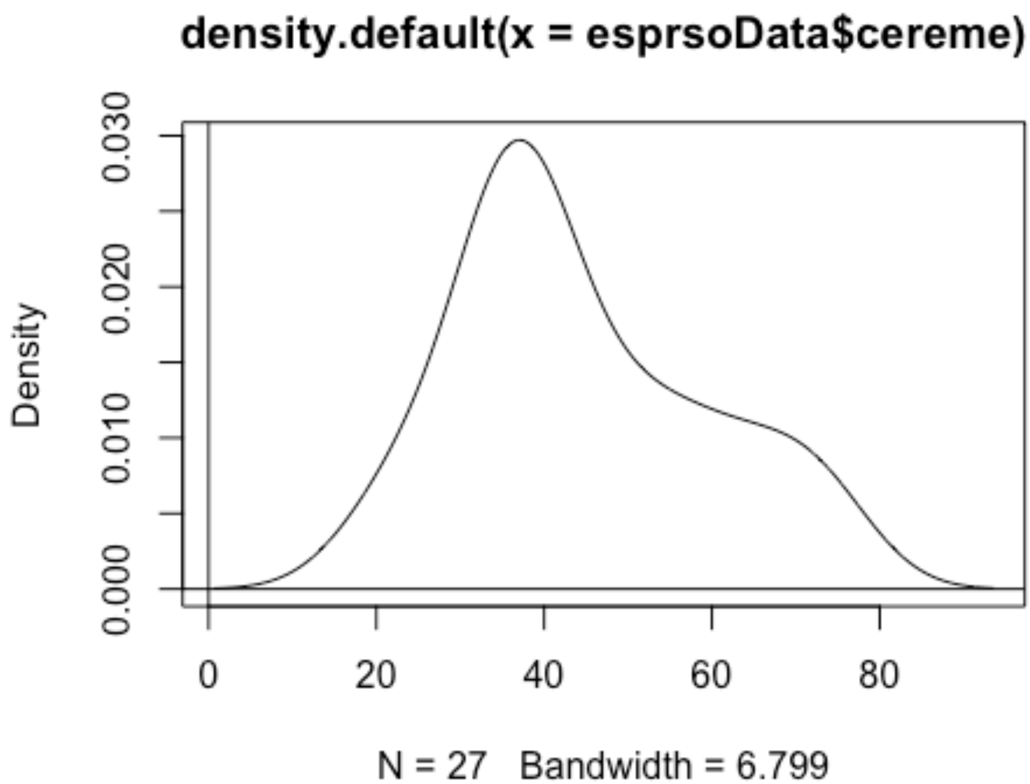
```r
esprsoData <- read.csv('EspressoData.csv')

#Formating the data
esprsoData$brewmethod <- as.factor(esprsoData$brewmethod)
str(esprsoData)
```

```
## 'data.frame':    27 obs. of  2 variables:
##  $ cereme    : num  36.6 39.6 37.7 36 38.5 ...
##  $ brewmethod: Factor w/ 3 levels "1","2","3": 1 1 1 1 1 1 1 1 1 2 ...
```

```r
summary(esprsoData)
```

```
##      cereme        brewmethod
##  Min.   :21.02   1:9
##  1st Qu.:35.66   2:9
##  Median :38.52   3:9
##  Mean   :44.47
##  3rd Qu.:55.23
##  Max.   :73.19
```

```r
plot(density(esprsoData$cereme))
abline(0,0, v = 0)
```



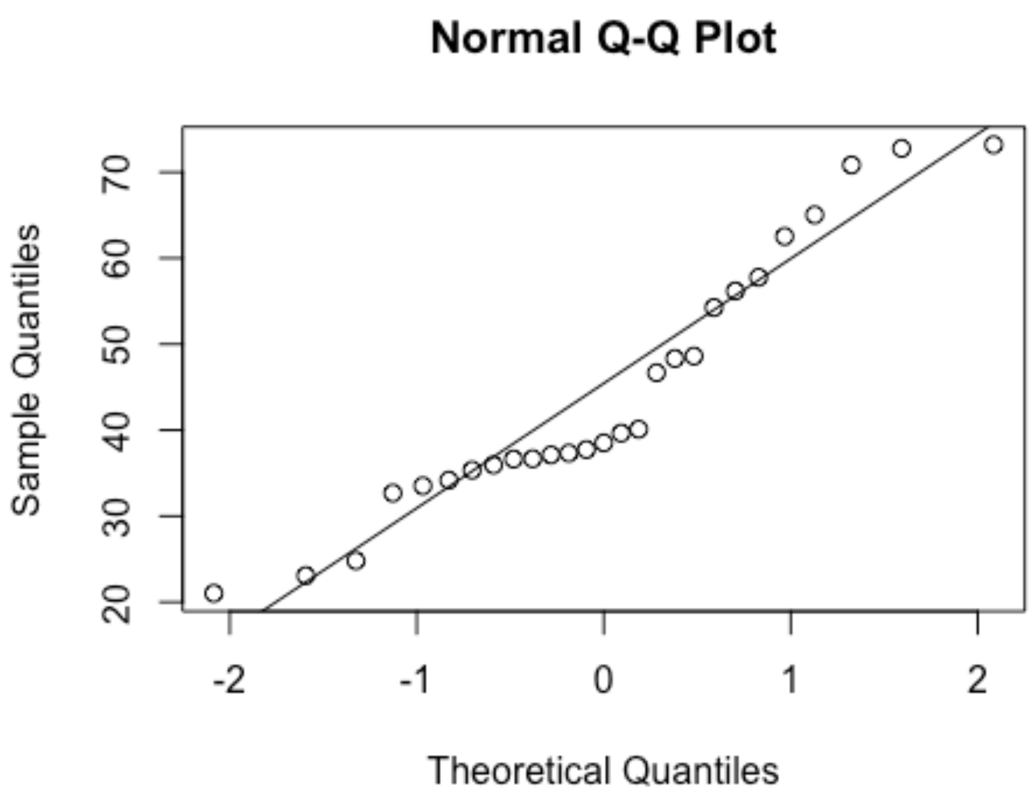

```r
library(moments)
agostino.test(esprsoData$cereme)
```

```
##
##  D'Agostino skewness test
##
## data:  esprsoData$cereme
## skew = 0.54679, z = 1.32787, p-value = 0.1842
## alternative hypothesis: data have a skewness
```

```r
shapiro.test(esprsoData$cereme)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  esprsoData$cereme
## W = 0.92201, p-value = 0.04414
```

```
qqnorm(esprsoData$cereme)
qqline(esprsoData$cereme)
```

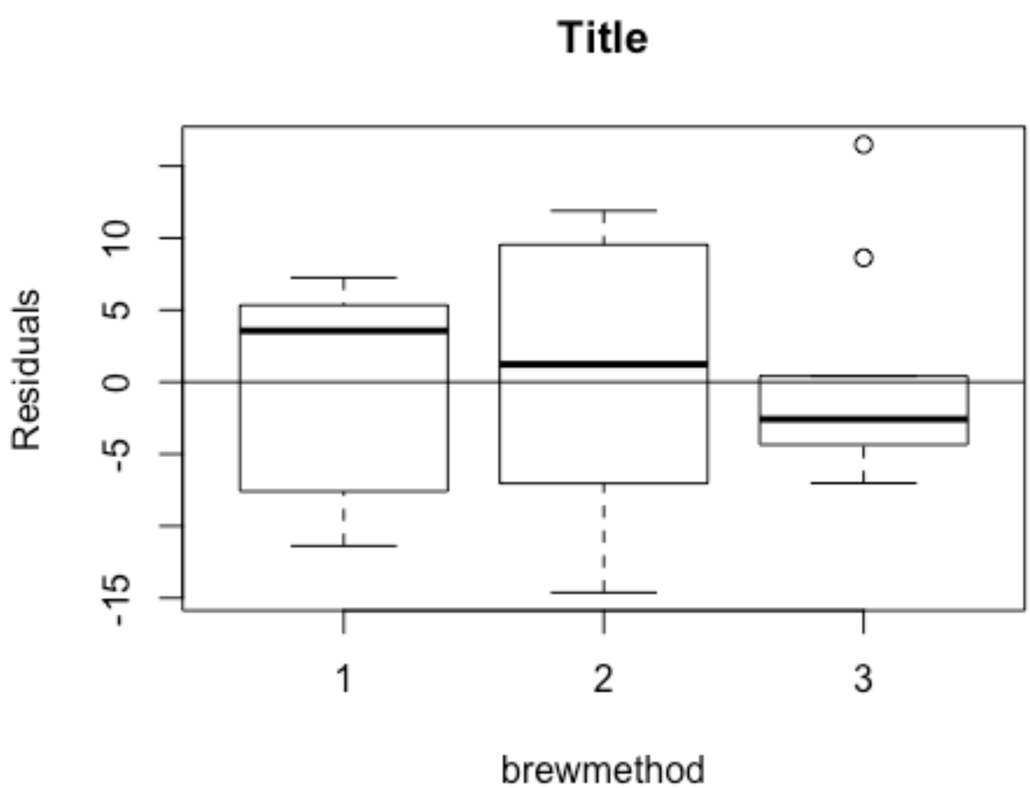



```
linearRegression = lm(cereme ~ brewmethod, data = esprsoData)
standardized = rstudent(linearRegression)
fitted = scale(linearRegression$fitted.values)
summary(linearRegression, correlation = T)
```

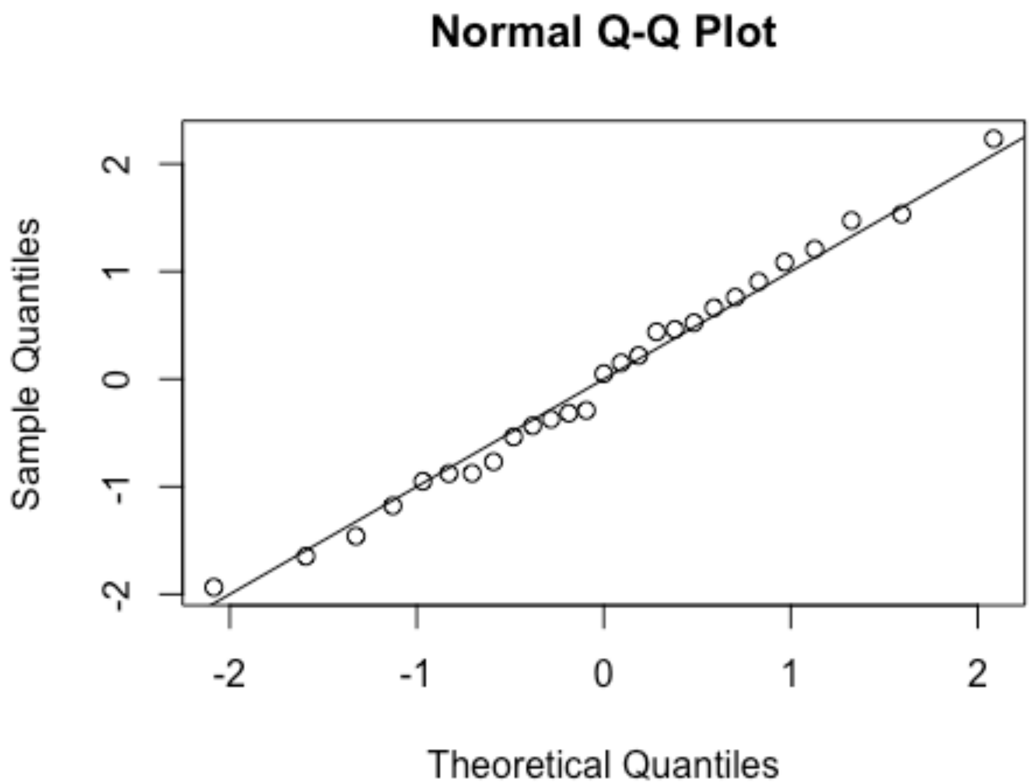
```
##
## Call:
## lm(formula = cereme ~ brewmethod, data = esprsoData)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -14.62  -6.60   0.41   5.73  16.49
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)   32.400      2.819  11.492 3.04e-11 ***
## brewmethod2   28.900      3.987   7.248 1.73e-07 ***
## brewmethod3    7.300      3.987   1.831   0.0796 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.458 on 24 degrees of freedom
## Multiple R-squared:  0.7031, Adjusted R-squared:  0.6783
## F-statistic: 28.41 on 2 and 24 DF,  p-value: 4.699e-07
##
## Correlation of Coefficients:
##             (Intercept) brewmethod2
## brewmethod2 -0.71
## brewmethod3 -0.71        0.50
```

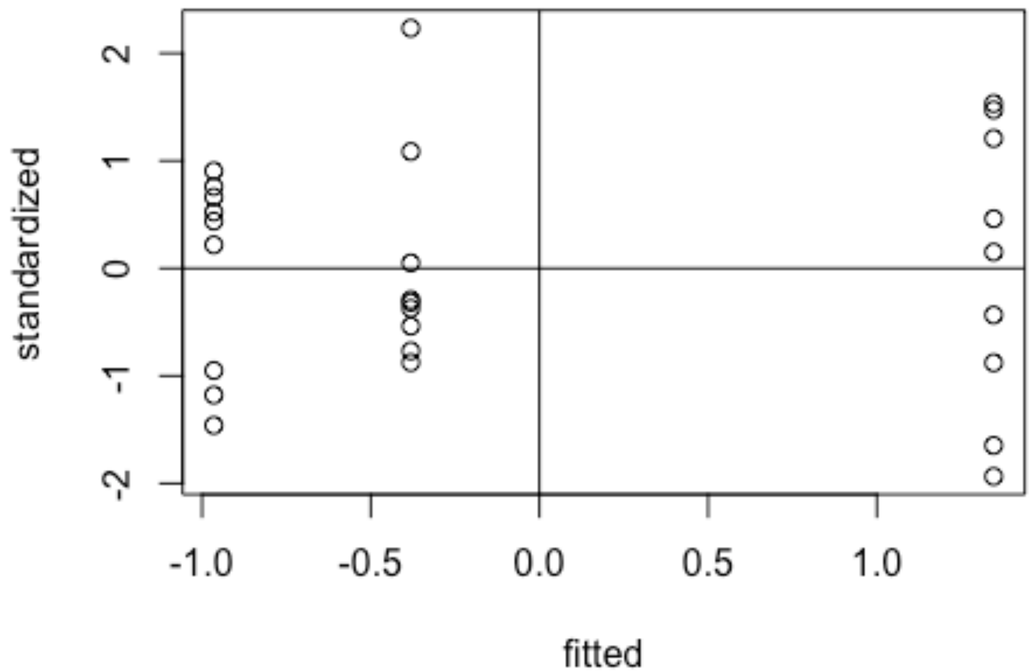
```r
linearRegressionModal = lm(cereme ~ brewmethod, data=esprsoData)
residual = resid(linearRegressionModal)
plot(esprsoData$brewmethod, residual, ylab= "Residuals", xlab = "brewmethod",
main = "Title")
abline(0, 0)
```




```r
qqnorm(standardized)
abline(0,1)
```




```
bartlett.test(esprsoData$cereme, esprsoData$brewmethod)

##
##  Bartlett test of homogeneity of variances
##
## data:  esprsoData$cereme and esprsoData$brewmethod
## Bartlett's K-squared = 0.96331, df = 2, p-value = 0.6178

tapply(esprsoData$cereme, esprsoData$brewmethod, var)

##         1         2         3
##  53.29088 102.02220  59.30182

plot(fitted, standardized)
abline(0,0, v = 0)
```




```
summary(aov(cereme ~ brewmethod, data = esprsoData))

##             Df Sum Sq Mean Sq F value  Pr(>F)
## brewmethod   2   4065  2032.6   28.41 4.7e-07 ***
## Residuals   24   1717    71.5
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

model <- aov(cereme ~ brewmethod, data = esprsoData)

TukeyHSD(model)

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = cereme ~ brewmethod, data = esprsoData)
##
## $brewmethod
##      diff        lwr       upr     p adj
## 2-1  28.9  18.942931  38.85707 0.0000005
## 3-1   7.3  -2.657069  17.25707 0.1811000
## 3-2 -21.6 -31.557069 -11.64293 0.0000419
```

```r
library(pastecs)
library(compute.es)

by(esprsoData$cereme, esprsoData$brewmethod, stat.desc)
```

```
## esprsoData$brewmethod: 1
##      nbr.val     nbr.null       nbr.na          min          max
range
##    9.0000000    0.0000000    0.0000000   21.0200000   39.6500000
18.6300000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##  291.6000000   35.9600000   32.4000000    2.4333533    5.6113228
53.2908750
##      std.dev     coef.var
##    7.3000599    0.2253105
## --------------------------------------------------------------
## esprsoData$brewmethod: 2
##      nbr.val     nbr.null       nbr.na          min          max
range
##    9.0000000    0.0000000    0.0000000   46.6800000   73.1900000
26.5100000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##  551.7000000   62.5300000   61.3000000    3.3668680    7.7640115
102.0222000
##      std.dev     coef.var
##   10.1006039    0.1647733
## --------------------------------------------------------------
## esprsoData$brewmethod: 3
##      nbr.val     nbr.null       nbr.na          min          max
range
##     9.000000     0.000000     0.000000    32.680000    56.190000
23.510000
##          sum       median         mean      SE.mean CI.mean.0.95
var
##   357.300000    37.120000    39.700000     2.566923     5.919334
59.301825
##      std.dev     coef.var
##     7.700768     0.193974
```

```r
modal12 <- mes(32.4, 61.3, 7.3, 10.1, 9, 9)
```

```
## Mean Differences ES:
##
##  d [ 95 %CI] = -3.28 [ -4.69 , -1.86 ]
##   var(d) = 0.52
##   p-value(d) = 0
##   U3(d) = 0.05 %
##   CLES(d) = 1.02 %
```

```
##   Cliff's Delta = -0.98
##
##  g [ 95 %CI] = -3.12 [ -4.47 , -1.78 ]
##   var(g) = 0.47
##   p-value(g) = 0
##   U3(g) = 0.09 %
##   CLES(g) = 1.36 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = -0.87 [ -0.95 , -0.67 ]
##   var(r) = 0
##   p-value(r) = 0
##
##  z [ 95 %CI] = -1.32 [ -1.83 , -0.81 ]
##   var(z) = 0.07
##   p-value(z) = 0
##
##  Odds Ratio ES:
##
##  OR [ 95 %CI] = 0 [ 0 , 0.03 ]
##   p-value(OR) = 0
##
##  Log OR [ 95 %CI] = -5.95 [ -8.51 , -3.38 ]
##   var(lOR) = 1.71
##   p-value(Log OR) = 0
##
##  Other:
##
##  NNT = -5
##  Total N = 18
```

```
modal12
```

```
##   N.total n.1 n.2     d var.d   l.d   u.d U3.d cl.d cliffs.d pval.d     g
var.g
## 1      18   9   9 -3.28  0.52 -4.69 -1.86 0.05 1.02    -0.98      0 -3.12
0.47
##     l.g   u.g U3.g cl.g pval.g     r var.r   l.r   u.r pval.r fisher.z
var.z
## 1 -4.47 -1.78 0.09 1.36      0 -0.87     0 -0.95 -0.67      0    -1.32
0.07
##     l.z   u.z OR l.or u.or pval.or   lOR l.lor u.lor pval.lor NNT
## 1 -1.83 -0.81  0    0 0.03       0 -5.95 -8.51 -3.38        0  -5
```

```
modal13 <- mes(32.4, 39.7, 7.3, 7.7, 9, 9)
```

```
## Mean Differences ES:
##
##  d [ 95 %CI] = -0.97 [ -1.95 , 0 ]
##   var(d) = 0.25
```

```
##   p-value(d) = 0.07
##   U3(d) = 16.53 %
##   CLES(d) = 24.57 %
##   Cliff's Delta = -0.51
##
##  g [ 95 %CI] = -0.93 [ -1.86 , 0 ]
##   var(g) = 0.23
##   p-value(g) = 0.07
##   U3(g) = 17.71 %
##   CLES(g) = 25.62 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = -0.46 [ -0.76 , 0.01 ]
##   var(r) = 0.03
##   p-value(r) = 0.07
##
##  z [ 95 %CI] = -0.5 [ -1 , 0.01 ]
##   var(z) = 0.07
##   p-value(z) = 0.07
##
##  Odds Ratio ES:
##
##  OR [ 95 %CI] = 0.17 [ 0.03 , 1.01 ]
##   p-value(OR) = 0.07
##
##  Log OR [ 95 %CI] = -1.76 [ -3.54 , 0.01 ]
##   var(lOR) = 0.82
##   p-value(Log OR) = 0.07
##
##  Other:
##
##  NNT = -6.05
##  Total N = 18
```

```
modal13
```

```
##   N.total n.1 n.2     d var.d   l.d u.d  U3.d  cl.d cliffs.d pval.d     g
var.g
## 1      18   9   9 -0.97  0.25 -1.95   0 16.53 24.57    -0.51   0.07 -0.93
0.23
##     l.g u.g  U3.g  cl.g pval.g     r var.r   l.r  u.r pval.r fisher.z
var.z l.z
## 1 -1.86   0 17.71 25.62   0.07 -0.46  0.03 -0.76 0.01   0.07     -0.5
0.07  -1
##    u.z   OR l.or u.or pval.or   lOR l.lor u.lor pval.lor   NNT
## 1 0.01 0.17 0.03 1.01    0.07 -1.76 -3.54  0.01     0.07 -6.05
```

```
modal23 <- mes(61.3, 39.7, 10.1, 7.7, 9, 9)
```

```
## Mean Differences ES:
##
##  d [ 95 %CI] = 2.41 [ 1.19 , 3.62 ]
##   var(d) = 0.38
##   p-value(d) = 0
##   U3(d) = 99.19 %
##   CLES(d) = 95.55 %
##   Cliff's Delta = 0.91
##
##  g [ 95 %CI] = 2.29 [ 1.14 , 3.45 ]
##   var(g) = 0.35
##   p-value(g) = 0
##   U3(g) = 98.9 %
##   CLES(g) = 94.74 %
##
##  Correlation ES:
##
##  r [ 95 %CI] = 0.79 [ 0.51 , 0.92 ]
##   var(r) = 0.01
##   p-value(r) = 0
##
##  z [ 95 %CI] = 1.06 [ 0.56 , 1.57 ]
##   var(z) = 0.07
##   p-value(z) = 0
##
##  Odds Ratio ES:
##
##  OR [ 95 %CI] = 78.46 [ 8.69 , 707.96 ]
##   p-value(OR) = 0
##
##  Log OR [ 95 %CI] = 4.36 [ 2.16 , 6.56 ]
##   var(lOR) = 1.26
##   p-value(Log OR) = 0
##
##  Other:
##
##  NNT = 1.35
##  Total N = 18
```

```
modal23
```

```
##   N.total n.1 n.2    d var.d  l.d  u.d  U3.d  cl.d cliffs.d pval.d    g
var.g
## 1      18   9   9 2.41  0.38 1.19 3.62 99.19 95.55     0.91      0 2.29
0.35
##    l.g  u.g U3.g  cl.g pval.g    r var.r  l.r  u.r pval.r fisher.z var.z
l.z
## 1 1.14 3.45 98.9 94.74      0 0.79  0.01 0.51 0.92      0     1.06  0.07
0.56
```

```
##    u.z    OR l.or   u.or pval.or  lOR l.lor u.lor pval.lor  NNT
## 1 1.57 78.46 8.69 707.96       0 4.36  2.16  6.56        0 1.35
```