

# BIOSTAT 650 Project

Jaehoon Kim (Group 19)

2024-11-17

```
df = NHANES
```

Initial data exploration of covariates that had a relation to SexAge were difficult to perform a correlation plot due to being factors.

```
covariates = c("SexAge", "Gender", "HHIncome", "Education", "PhysActive", "SameSex", "AlcoholYear", "RegularMarij")
sapply(df[, covariates], is.factor)
```

```
##      SexAge      Gender  HHIncome  Education  PhysActive  SameSex
##      FALSE      TRUE      TRUE      TRUE      TRUE      TRUE
## AlcoholYear RegularMarij  HardDrugs
##      FALSE      TRUE      TRUE
```

```
#M = cor(df[, covariates])
#corrplot(M, method = 'number')
```

Running different multiple linear regressions, we found two models of interest after some exploratory data analysis with different covariates for which statistical significance persisted even after controlling for some social demographic covariates.

```
model <- lm(SexAge ~ RegularMarij+HardDrugs+RegularMarij*HardDrugs, df)
summary(model)
```

```
##
## Call:
## lm(formula = SexAge ~ RegularMarij + HardDrugs + RegularMarij *
##      HardDrugs, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -9.0399 -2.0399 -0.3123  1.1842 28.9601
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    18.03995     0.06268  287.823   < 2e-16 ***
## RegularMarijYes    -2.22420     0.14750  -15.080   < 2e-16 ***
## HardDrugsYes       -1.72766     0.20925   -8.256   < 2e-16 ***
## RegularMarijYes:HardDrugsYes  1.44824     0.28116    5.151  2.7e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.464 on 4712 degrees of freedom
## (5284 observations deleted due to missingness)
## Multiple R-squared:  0.08977, Adjusted R-squared:  0.08919
## F-statistic: 154.9 on 3 and 4712 DF, p-value: < 2.2e-16
```

```
model <- lm(SexNumPartnLife ~ RegularMarij+HardDrugs+RegularMarij*HardDrugs, df)
summary(model)
```

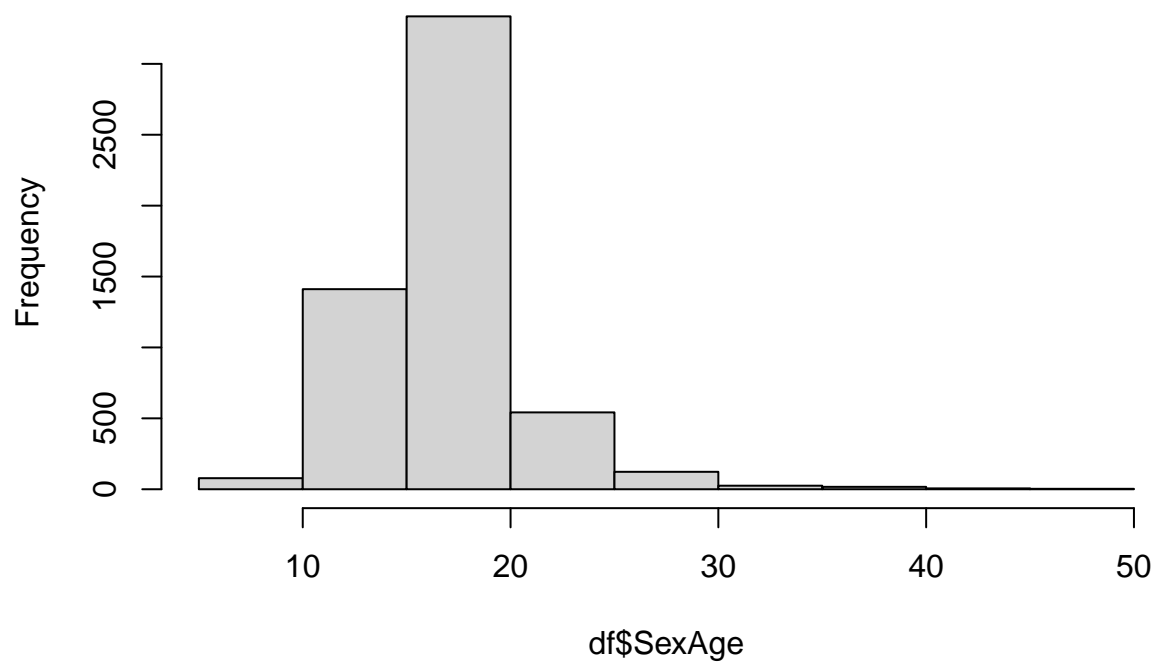
```
##
## Call:
## lm(formula = SexNumPartnLife ~ RegularMarij + HardDrugs + RegularMarij *
##     HardDrugs, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -37.59   -8.41   -5.41   -0.41  1991.59
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      8.4060     1.0513   7.996 1.59e-15 ***
## RegularMarijYes    14.8056     2.5393   5.831 5.88e-09 ***
## HardDrugsYes       13.5674     3.6078   3.761 0.000171 ***
## RegularMarijYes:HardDrugsYes  0.8151     4.8573   0.168 0.866740
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 59.88 on 4897 degrees of freedom
## (5099 observations deleted due to missingness)
## Multiple R-squared:  0.03038,    Adjusted R-squared:  0.02978
## F-statistic: 51.14 on 3 and 4897 DF,  p-value: < 2.2e-16
```

SexAge is has a good distribution but SexNumPartnLife has extreme skewness and is discrete count data. This requires a Poisson regression which is out side the scope of this course. Created new variable using the duration, since first sexual activity where (Age - SexAge) since Age >= SexAge, and dividing by the number of sexual partners in life to see frequency of sexual activity. New variable was log transformed due to extreme skewness that violated normality assumption, which could be checked by QQPlot.

Due to extreme skewness, we tried to find some observations that had implausible reported data that could been a typo or non serious answer. For instance, observations 8576 and 3416 reported to have had a first sexual activity at 9 with 360 and 500 sexual partners in life, respectively. Observations 4579 and 4580 reported to have had a first sexual activity at 10 and both reportedly had 700 sexual partners in life. Observations 4579 and 4580 reported to have had a first sexual activity at 10 and both reportedly had 700 sexual partners in life. We removed these outliers.

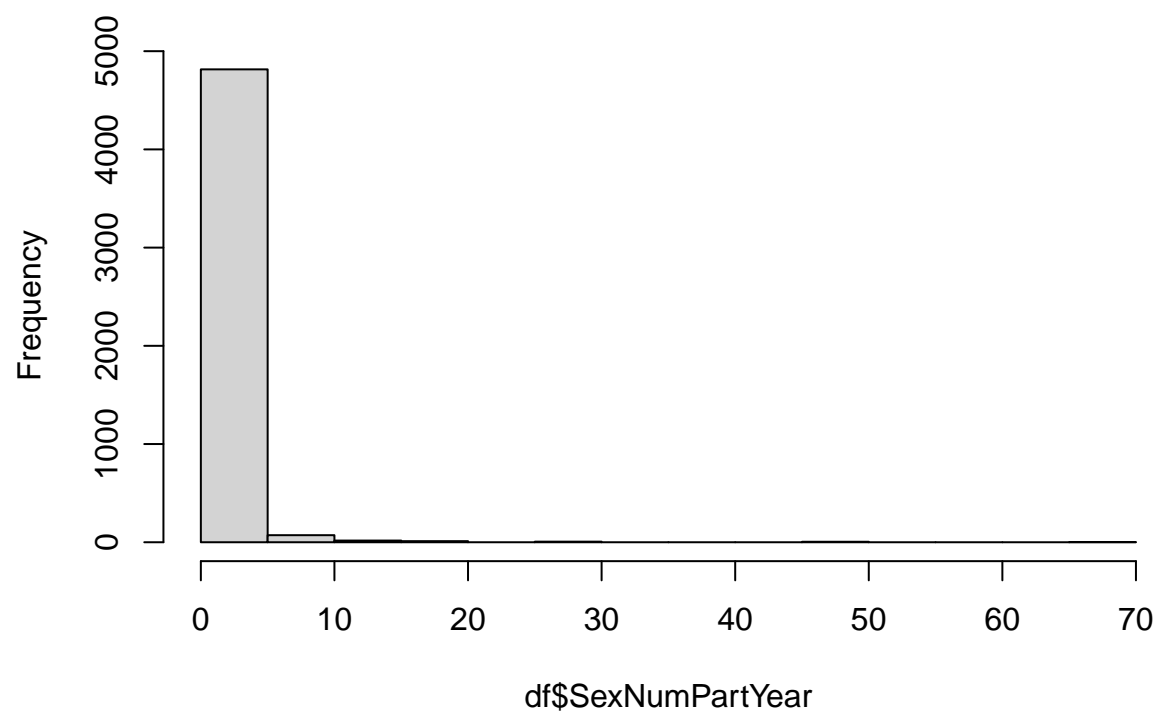
```
hist(df$SexAge, main= "First Age at which Sexual Activity Occured")
```

## First Age at which Sexual Activity Occured



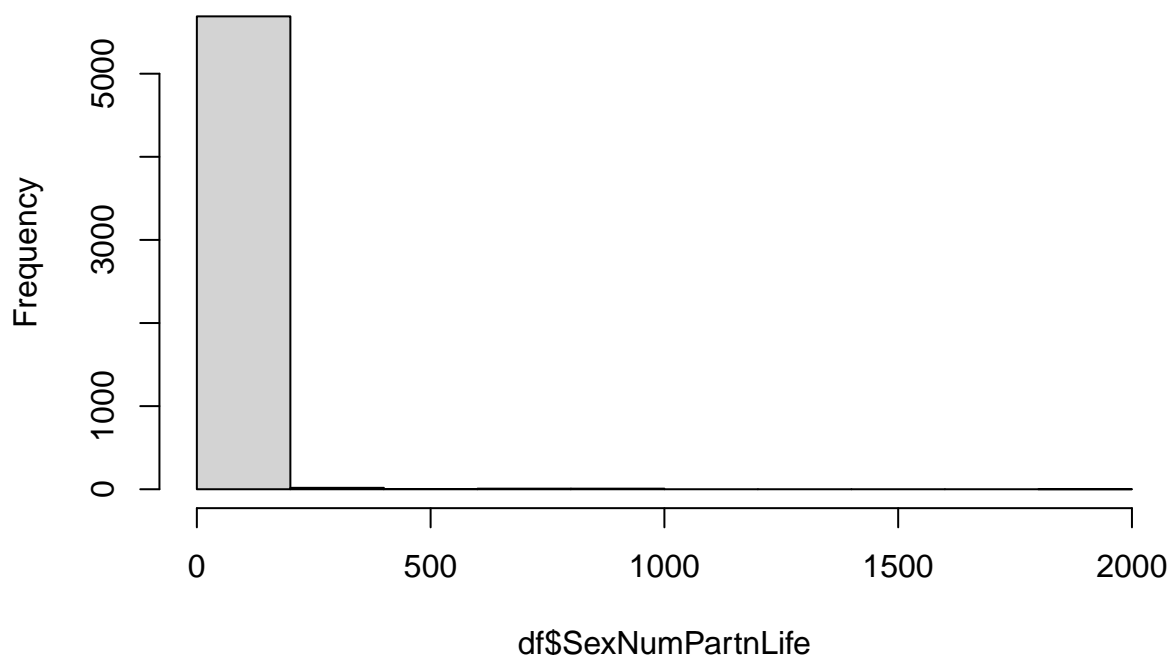
```
hist(df$SexNumPartYear, main = )
```

**Histogram of df\$SexNumPartYear**



```
hist(df$SexNumPartnLife)
```

## Histogram of df\$SexNumPartnLife



```
#Show observations with more than 300 sexual partners during lifetime
```

```
which(df$SexNumPartnLife > 300)
```

```
## [1] 1353 2764 3416 3724 3795 4579 4580 6964 6965 7953 7954 8122 8123 8124 8428
```

```
## [16] 8576 8651 8838 8839 9596 9597 9598 9599 9600 9730
```

```
df[which(df$SexNumPartnLife > 300), c("Age", "SexAge", "SexNumPartnLife")]
```

```
## # A tibble: 25 x 3
```

```
##   Age SexAge SexNumPartnLife
```

```
##   <int> <int>         <int>
```

```
## 1    63     18           301
```

```
## 2    54     13          1000
```

```
## 3    63      9           500
```

```
## 4    57     13          1000
```

```
## 5    42     14           560
```

```
## 6    49     10           700
```

```
## 7    49     10           700
```

```
## 8    23     11           340
```

```
## 9    23     11           340
```

```
## 10   50     15          1000
```

```
## # i 15 more rows
```

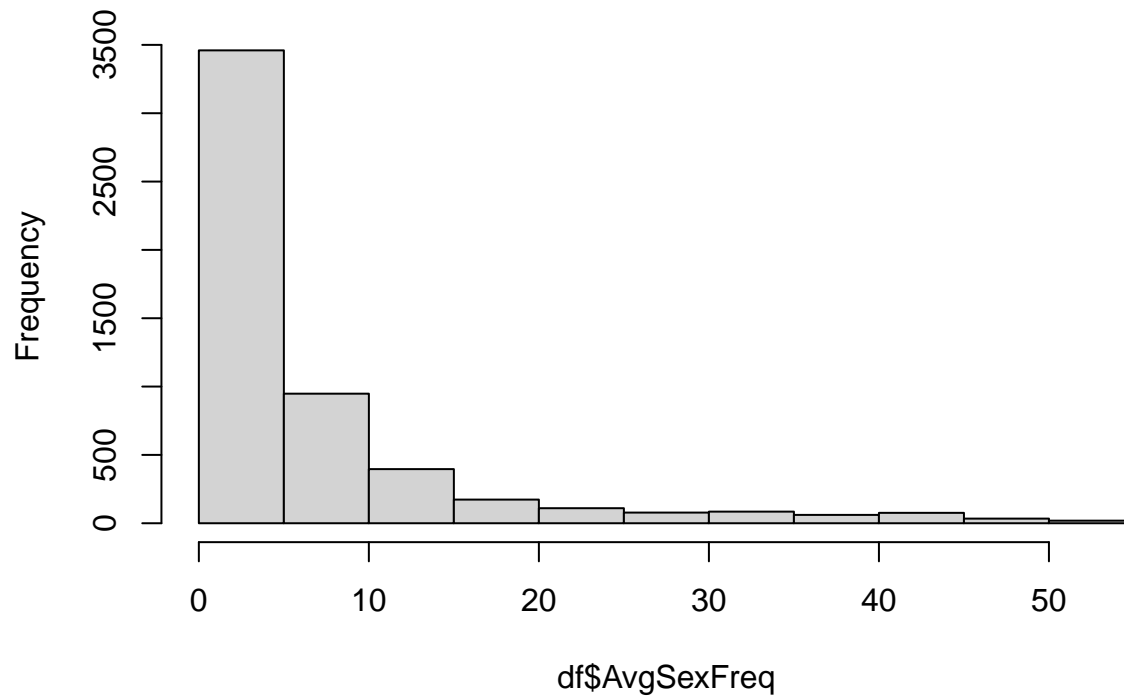
```
df = df[-which(df$SexNumPartnLife > 300),]
```

```
#Before log transformation
```

```
df = mutate(df, AvgSexFreq = (Age-SexAge)/SexNumPartnLife)
```

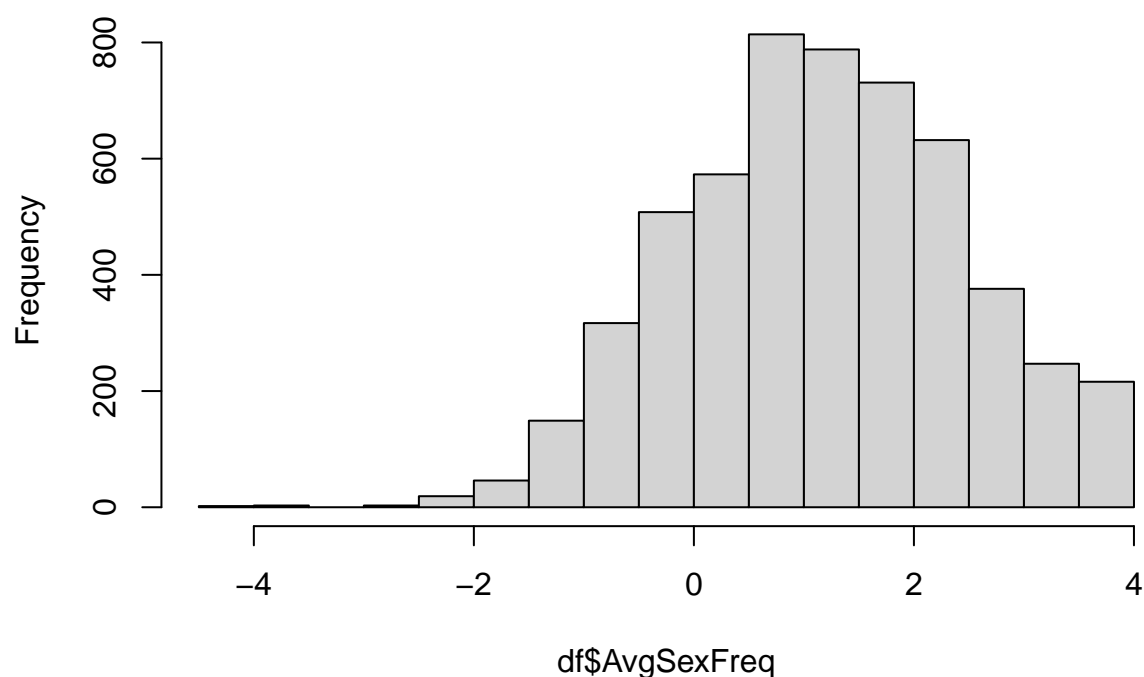
```
hist(df$AvgSexFreq, main = "AvgSexFreq Before log transformation")
```

## AvgSexFreq Before log transformation



```
#After log transformation  
df = mutate(df, AvgSexFreq = log((Age-SexAge)/SexNumPartnLife))  
hist(df$AvgSexFreq, main = "AvgSexFreq After log transformation")
```

## AvgSexFreq After log transformation



```
#Remove negative infinity
df$AvgSexFreq[is.infinite(df$AvgSexFreq)] = NA
#unique(df$AvgSexFreq)

df$nPregnancies = is.factor(df$nPregnancies)
model <- lm(AvgSexFreq ~ SmokeNow+AlcoholYear+RegularMarij+HardDrugs+RegularMarij*HardDrugs+Age+Gender+
summary(model)
```

```
##
## Call:
## lm(formula = AvgSexFreq ~ SmokeNow + AlcoholYear + RegularMarij +
##      HardDrugs + RegularMarij * HardDrugs + Age + Gender + HHIncome +
##      Education + BMI + DiabetesAge + Depressed + LittleInterest +
##      PhysActive + SameSex, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.3555 -0.2319  0.1070  0.3372  1.8233
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -1.638326   1.431952  -1.144   0.2580
## SmokeNowYes     0.317798   0.315754   1.006   0.3190
## AlcoholYear    -0.002355   0.001688  -1.395   0.1691
## RegularMarijYes  0.643604   0.320484   2.008   0.0500 .
## HardDrugsYes   -1.231593   0.614234  -2.005   0.0504 .
```

```
## Age 0.051987 0.024085 2.158 0.0357 *
## Gendermale -1.340728 0.274434 -4.885 1.1e-05 ***
## HHIncome 5000-9999 -0.566871 0.629365 -0.901 0.3721
## HHIncome10000-14999 -1.081820 0.543756 -1.990 0.0521 .
## HHIncome15000-19999 0.903343 0.878828 1.028 0.3089
## HHIncome20000-24999 -0.356869 0.595470 -0.599 0.5517
## HHIncome25000-34999 -0.293062 0.565401 -0.518 0.6065
## HHIncome35000-44999 0.156911 0.525551 0.299 0.7665
## HHIncome45000-54999 -1.873535 0.756699 -2.476 0.0167 *
## HHIncome55000-64999 0.636927 0.613700 1.038 0.3043
## HHIncome65000-74999 -0.698542 0.612030 -1.141 0.2592
## HHIncome75000-99999 -0.407544 0.628229 -0.649 0.5195
## HHIncomemore 99999 -0.903659 0.530698 -1.703 0.0948 .
## Education9 - 11th Grade -0.508748 0.491227 -1.036 0.3053
## EducationHigh School 0.333135 0.550048 0.606 0.5475
## EducationSome College 0.238200 0.489435 0.487 0.6286
## EducationCollege Grad 1.017370 0.611602 1.663 0.1025
## BMI 0.025369 0.017988 1.410 0.1646
## DiabetesAge 0.002411 0.014928 0.162 0.8723
## DepressedSeveral -0.177637 0.363140 -0.489 0.6269
## DepressedMost 0.236648 0.436207 0.543 0.5899
## LittleInterestSeveral -0.066404 0.337355 -0.197 0.8448
## LittleInterestMost 0.510451 0.377313 1.353 0.1822
## PhysActiveYes -0.059868 0.332020 -0.180 0.8576
## SameSexYes 0.046164 0.490791 0.094 0.9254
## RegularMarijYes:HardDrugsYes 0.675466 0.704185 0.959 0.3421
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7339 on 50 degrees of freedom
## (9894 observations deleted due to missingness)
## Multiple R-squared: 0.7363, Adjusted R-squared: 0.578
## F-statistic: 4.653 on 30 and 50 DF, p-value: 8.649e-07
```

```
model |>
tbl_regression(intercept = TRUE)
```

Characteristic	Beta	95% CI <sup>1</sup>	p-value
(Intercept)	-1.6	-4.5, 1.2	0.3
SmokeNow			
No	—	—	
Yes	0.32	-0.32, 0.95	0.3
AlcoholYear	0.00	-0.01, 0.00	0.2
RegularMarij			
No	—	—	
Yes	0.64	0.00, 1.3	0.050
HardDrugs			
No	—	—	
Yes	-1.2	-2.5, 0.00	0.050
Age	0.05	0.00, 0.10	0.036
Gender			



female	—	—	
male	-1.3	-1.9, -0.79	<0.001
HHIncome			
0-4999	—	—	
5000-9999	-0.57	-1.8, 0.70	0.4
10000-14999	-1.1	-2.2, 0.01	0.052
15000-19999	0.90	-0.86, 2.7	0.3
20000-24999	-0.36	-1.6, 0.84	0.6
25000-34999	-0.29	-1.4, 0.84	0.6
35000-44999	0.16	-0.90, 1.2	0.8
45000-54999	-1.9	-3.4, -0.35	0.017
55000-64999	0.64	-0.60, 1.9	0.3
65000-74999	-0.70	-1.9, 0.53	0.3
75000-99999	-0.41	-1.7, 0.85	0.5
more 99999	-0.90	-2.0, 0.16	0.095
Education			
8th Grade	—	—	
9 - 11th Grade	-0.51	-1.5, 0.48	0.3
High School	0.33	-0.77, 1.4	0.5
Some College	0.24	-0.74, 1.2	0.6
College Grad	1.0	-0.21, 2.2	0.10
BMI	0.03	-0.01, 0.06	0.2
DiabetesAge	0.00	-0.03, 0.03	0.9
Depressed			
None	—	—	
Several	-0.18	-0.91, 0.55	0.6
Most	0.24	-0.64, 1.1	0.6
LittleInterest			
None	—	—	
Several	-0.07	-0.74, 0.61	0.8
Most	0.51	-0.25, 1.3	0.2
PhysActive			
No	—	—	
Yes	-0.06	-0.73, 0.61	0.9
SameSex			
No	—	—	
Yes	0.05	-0.94, 1.0	>0.9
RegularMarij * HardDrugs			
Yes * Yes	0.68	-0.74, 2.1	0.3

<sup>1</sup> CI = Confidence Interval

```
#model <- lm(AvgSexFreq ~ #Gender+HHIncome+Education+PhysActive+SameSex+AlcoholYear+RegularMarij+HardDrugs)
#summary(model)
```

Using the sequential sum of squares we tested for each block of covariates at a significance level 0.05

```
n = 50
aov = anova(model <- lm(AvgSexFreq ~ SmokeNow+AlcoholYear+RegularMarij+HardDrugs+RegularMarij*HardDrugs
aov
```

```
## Analysis of Variance Table
##
## Response: AvgSexFreq
##
##      Df Sum Sq Mean Sq F value    Pr(>F)
## SmokeNow      1  0.7399   0.7399   1.3736 0.2467482
## AlcoholYear    1  6.3185   6.3185  11.7302 0.0012368 **
## RegularMarij    1  0.2515   0.2515   0.4670 0.4975312
## HardDrugs       1  6.0788   6.0788  11.2852 0.0015019 **
## Age            1 14.9093  14.9093  27.6786 3.000e-06 ***
## Gender          1 16.2649  16.2649  30.1952 1.318e-06 ***
## HHIncome       11 21.9288   1.9935   3.7009 0.0006885 ***
## Education       4  2.5118   0.6279   1.1658 0.3371471
## BMI             1  1.5849   1.5849   2.9423 0.0924794 .
## DiabetesAge     1  0.0722   0.0722   0.1340 0.7158242
## Depressed       2  2.3338   1.1669   2.1663 0.1252382
## LittleInterest  2  1.6380   0.8190   1.5205 0.2285478
## PhysActive      1  0.0568   0.0568   0.1054 0.7467409
## SameSex         1  0.0017   0.0017   0.0032 0.9553125
## RegularMarij:HardDrugs 1  0.4956   0.4956   0.9201 0.3420654
## Residuals      50 26.9329   0.5387
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
SSY = sum(aov$"Sum Sq")
SSQ = aov$"Sum Sq"
MSE = aov$"Mean Sq"[16]
ss1 = sum(SSQ[c(1:4, 15)])
print(ss1)
```

```
## [1] 13.88444
fstat1 = ss1/5/MSE
pval1 = 1-pf(q = fstat1, df1 = 5, df2 = n-16)
print(c(fstat1, pval1))
```

```
## [1] 5.155204576 0.001262146
ss2 = sum(SSQ[5:8])
print(ss2)
```

```
## [1] 55.61473
fstat2 = ss2/4/MSE
pval2 = 1-pf(q = fstat2, df1 = 4, df2 = n-16)
print(c(fstat2, pval2))
```

```
## [1] 2.581174e+01 6.872507e-10
ss3 = sum(SSQ[9:14])
print(ss3)
```

```
## [1] 5.687399
```

```
fstat3 = ss3/5/MSE
pval3 = 1-pf(q = fstat3, df1 = 5, df2 = n-16)
print(c(fstat3, pval3))
```

```
## [1] 2.11169493 0.08788892
```

```
ss4 = sum(SSQ[14])
print(ss4)
```

```
## [1] 0.001708498
```

```
fstat4 = ss3/1/MSE
pval4 = 1-pf(q = fstat4, df1 = 1, df2 = n-16)
print(c(fstat4, pval4))
```

```
## [1] 10.55847467 0.00260712
```

- (i)  $\beta_{substance} = (\beta_{SmokeNow}, \beta_{AlcoholYear}, \beta_{RegularMarij}, \beta_{HardDrugs}, \beta_{RegularMarij*HardDrugs})^T$
- (ii)  $\beta_{Demo} = (\beta_{Age}, \beta_{Gender}, \beta_{HHIncome}, \beta_{Education})^T$
- (iii)  $\beta_{Health} = (\beta_{BMI}, \beta_{DiabetesAges}, \beta_{Depressed}, \beta_{LittleInterest}, \beta_{PhysActive})^T$
- (iv)  $\beta_{SameSex} = (\beta_{SameSex})^T$

Step	Tested Var.	SS(Num.)	SS(Denom.)	Test Stat.	Dist.	p-value	Decision	Stopping Rule	Decision
I	$\beta_{Substance}$	13.88444	26.9329	5.155204576	$F_{5,34}$	0.001262146	Reject	Do not stop	Collect
II	$\beta_{Demo}$	55.61473	26.9329	25.81174	$F_{4,34}$	6.872507e-10	Reject	Do not stop	Collect
III	$\beta_{Health}$	5.687399	26.9329	2.11169493	$F_{5,34}$	0.08788892	Fail to Reject	Stop	Not Collect
IV	$\beta_{SameSex}$	0.001708498	26.9329	10.55847467	$F_{1,34}$	0.00260712	NA	NA	NA

```
library(ggplot2)
library(tidyr)
#Add new column based on missingness
covariates = c("AvgSexFreq", "SmokeNow", "AlcoholYear", "RegularMarij", "HardDrugs", "Age", "Gender", "HHIncome")
sum(complete.cases(df[, covariates]))
```

```
## [1] 1782
```

```
df$missingness <- ifelse(complete.cases(df[, covariates]), "Missing", "Not Missing")
```

```
library(gridExtra)
```

```
## Warning: package 'gridExtra' was built under R version 4.4.2
```

```
##
```

```
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
## combine
```

```
p1 = ggplot(data = df, mapping=aes(x=SmokeNow, fill=as.factor(missingness)))+
  geom_bar(stat="count")+
  scale_fill_manual(values = c("gray", "red"))
p2 = ggplot(data = df, mapping=aes(x=AlcoholYear, fill=as.factor(missingness)))+
```

```

    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))
p3 = ggplot(data = df, mapping=aes(x=RegularMarij, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))
p4 = ggplot(data = df, mapping=aes(x=HardDrugs, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))

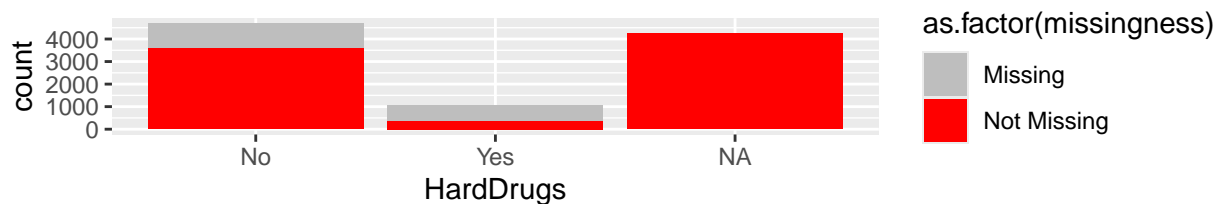
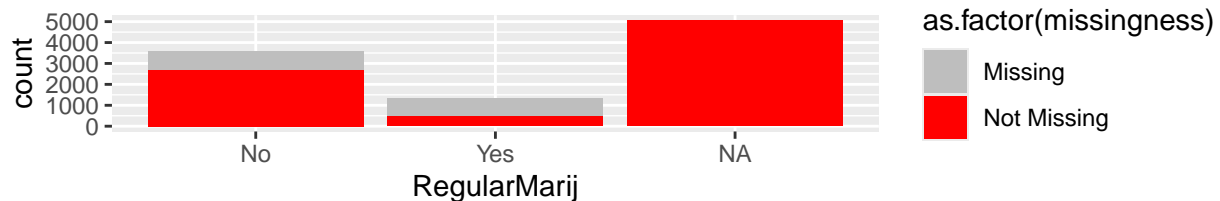
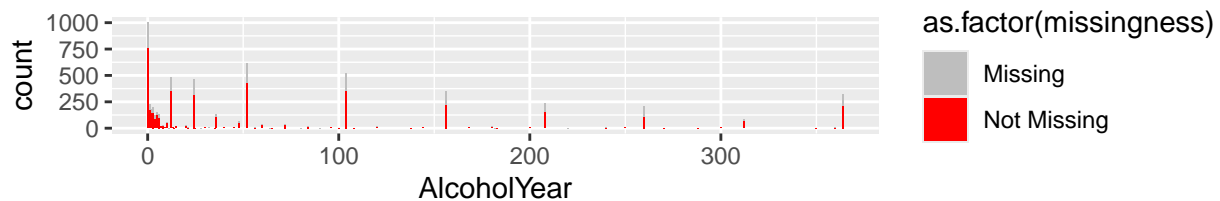
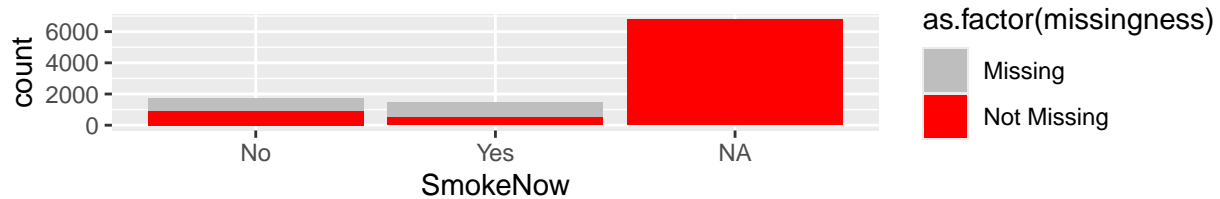
grid.arrange(p1,p2,p3,p4, nrow=4)

```

```

## Warning: Removed 4078 rows containing non-finite outside the scale range
## (`stat_count()`).

```

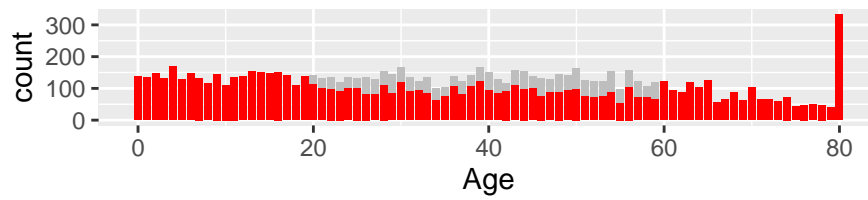


```

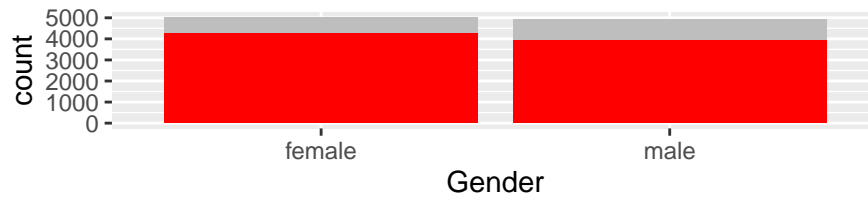
p6 = ggplot(data = df, mapping=aes(x=Age, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))
p7 = ggplot(data = df, mapping=aes(x=Gender, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))
p8 = ggplot(data = df, mapping=aes(x=HHIncome, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))
p9 = ggplot(data = df, mapping=aes(x=Education, fill=as.factor(missingness)))+
    geom_bar(stat="count")+
    scale_fill_manual(values = c("gray", "red"))

```

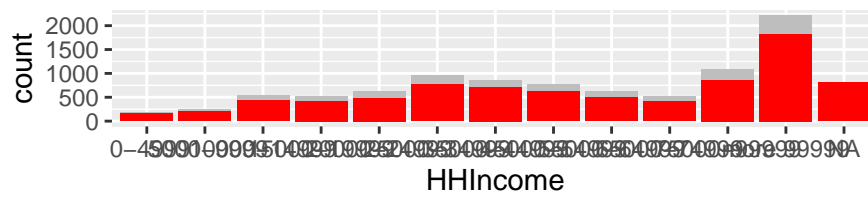
```
grid.arrange(p6, p7, p8, p9, nrow = 4)
```



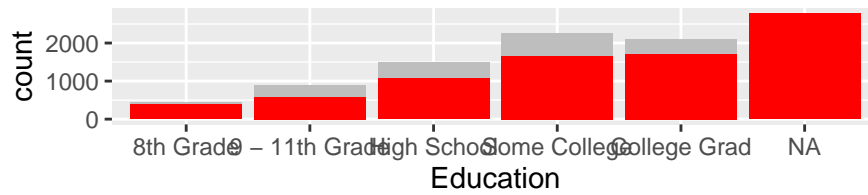
as.factor(missingness)



as.factor(missingness)



as.factor(missingness)

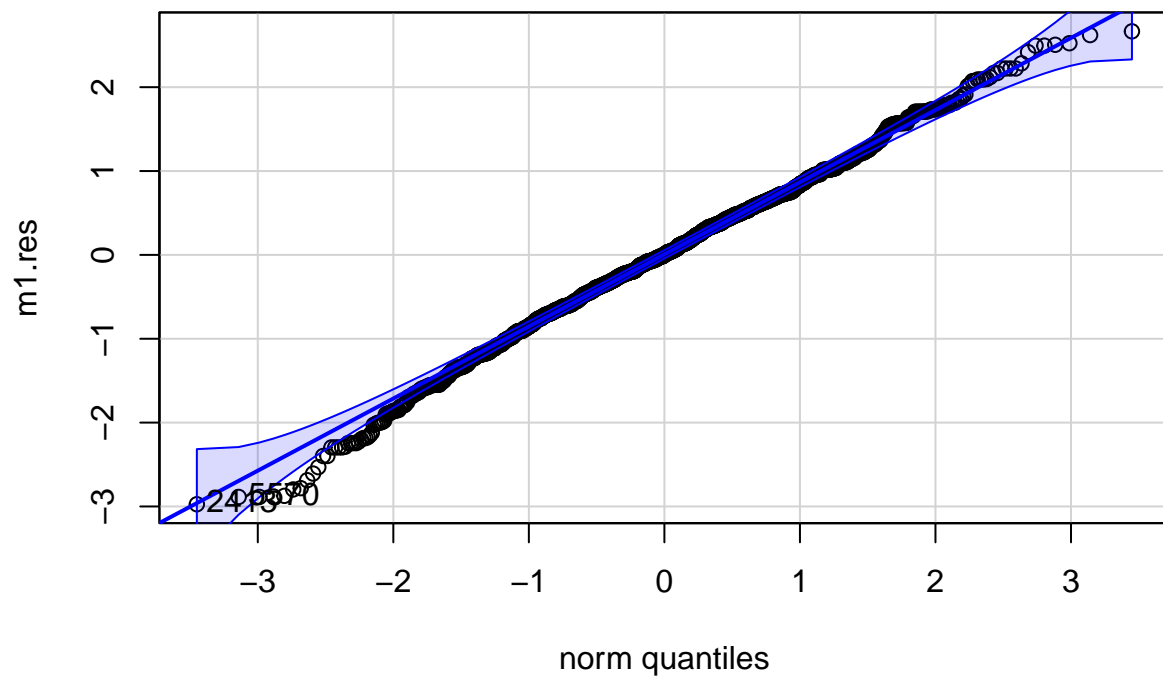


as.factor(missingness)

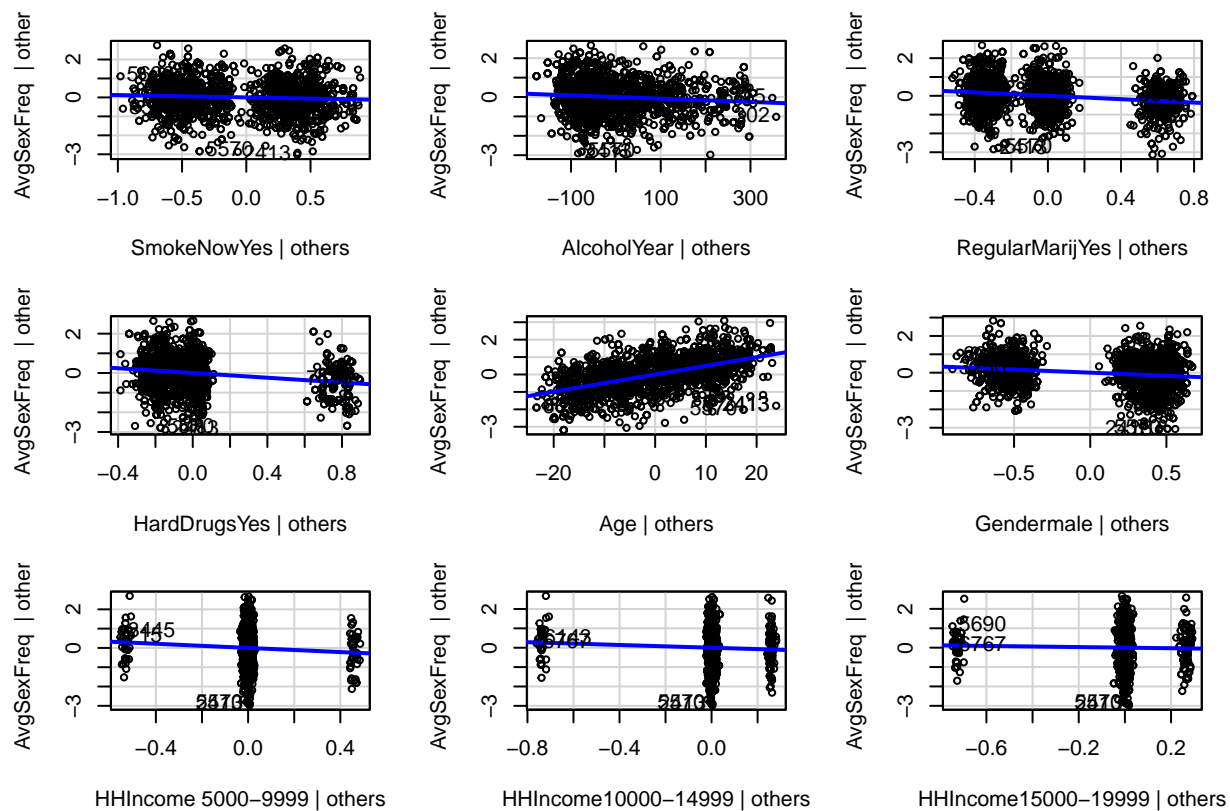


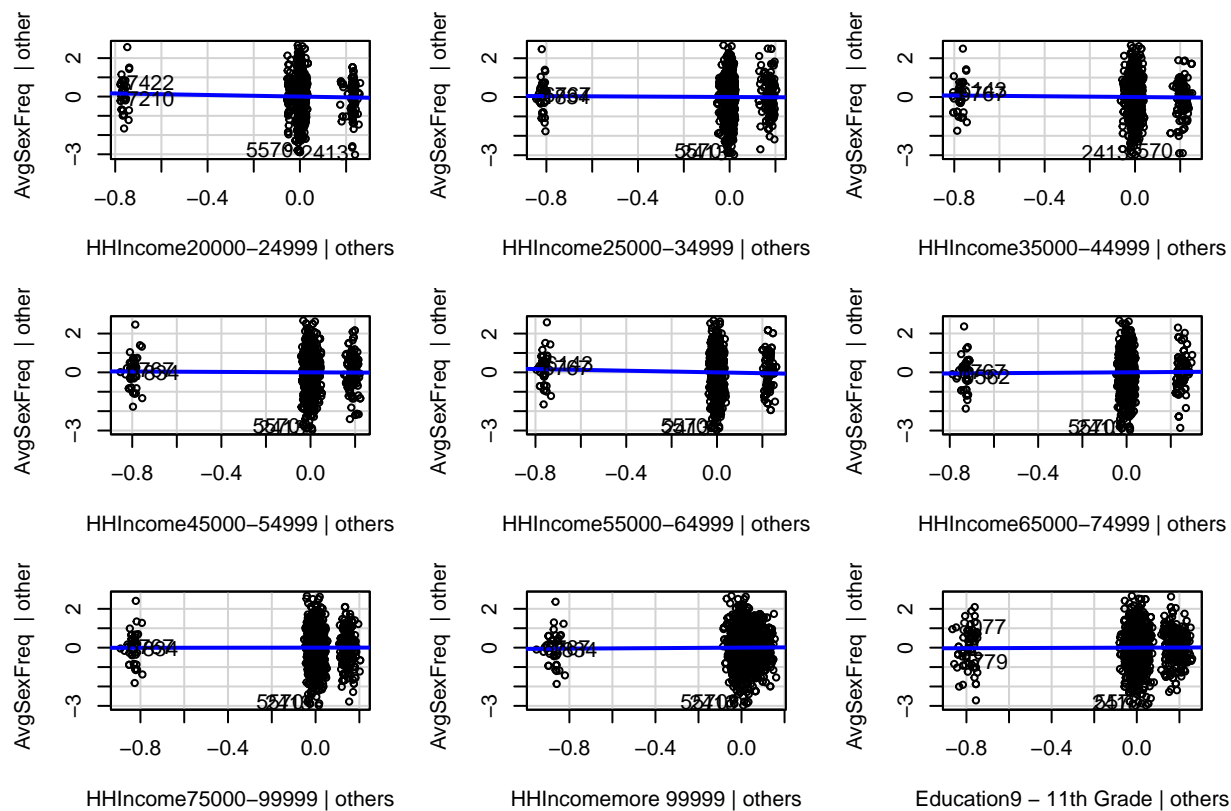
```
m1 = lm(AvgSexFreq ~ SmokeNow+AlcoholYear+RegularMarij+HardDrugs+RegularMarij*HardDrugs+Age+Gender+HHIncome)
m1.res = m1$residuals

car::qqPlot(m1.res)
```



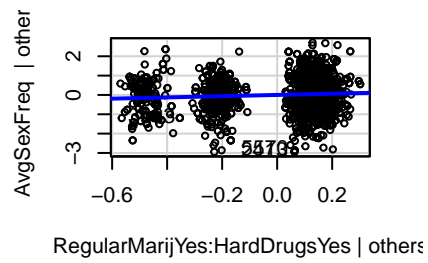
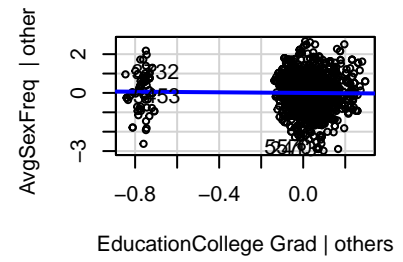
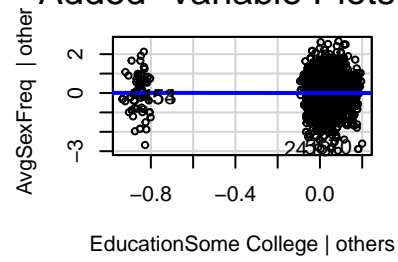
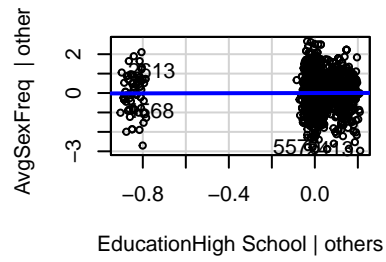
```
## 2413 5570
## 458 1030
car::avPlots(m1)
```



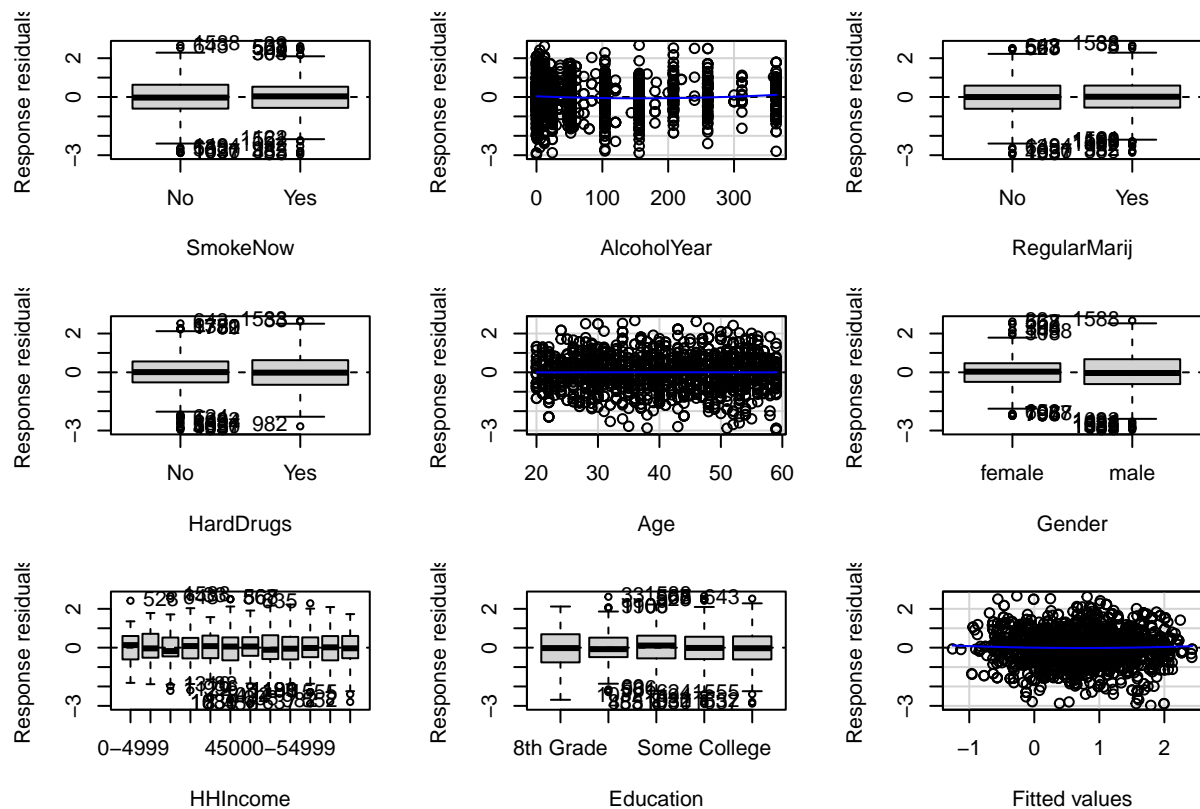




## Added-Variable Plots



```
car::residualPlots(m1, type="response")
```



```
##          Test stat Pr(>|Test stat|)
## SmokeNow
## AlcoholYear      2.3041      0.02134 *
## RegularMarij
## HardDrugs
## Age             -0.0525      0.95818
## Gender
## HHIncome
## Education
## Tukey test       0.9173      0.35898
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#interactions(???)
```

```
nonintmodel <- lm(AvgSexFreq ~ SmokeNow+AlcoholYear+RegularMarij+Age+Gender+HHIncome+Education, df)
car::vif(nonintmodel,type = 'predictor')
```

```
## GVIFs computed for predictors
```

```
##          GVIF Df GVIF^(1/(2*Df)) Interacts With
## SmokeNow    1.176162  1      1.084510      --
## AlcoholYear  1.121568  1      1.059041      --
## RegularMarij 1.036768  1      1.018218      --
## Age         1.093531  1      1.045720      --
## Gender      1.046471  1      1.022972      --
## HHIncome    1.437208 11      1.016623      --
## Education   1.418796  4      1.044696      --
```

```
##                                Other Predictors
## SmokeNow      AlcoholYear, RegularMarij, Age, Gender, HHIncome, Education
## AlcoholYear   SmokeNow, RegularMarij, Age, Gender, HHIncome, Education
## RegularMarij   SmokeNow, AlcoholYear, Age, Gender, HHIncome, Education
## Age           SmokeNow, AlcoholYear, RegularMarij, Gender, HHIncome, Education
## Gender        SmokeNow, AlcoholYear, RegularMarij, Age, HHIncome, Education
## HHIncome      SmokeNow, AlcoholYear, RegularMarij, Age, Gender, Education
## Education      SmokeNow, AlcoholYear, RegularMarij, Age, Gender, HHIncome
```

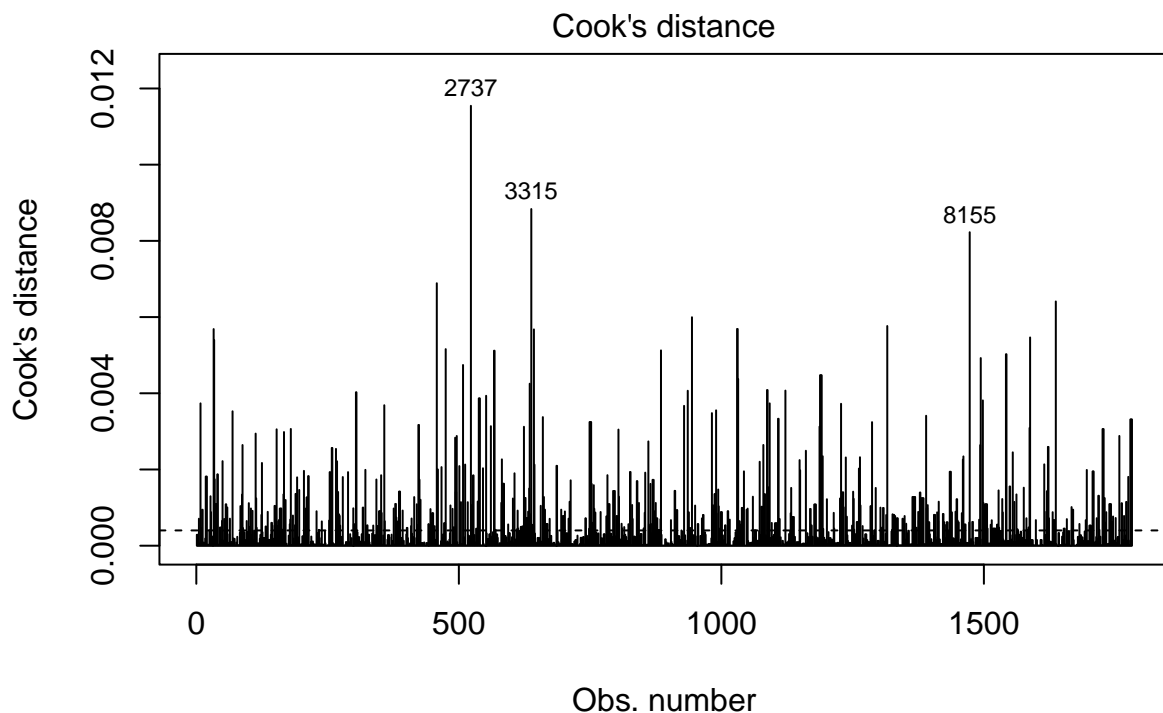
```
model.deffits=dffits(m1)
model.CD = cooks.distance(m1)
model.deffits[which.max(model.deffits)]
```

```
##      2737
## 0.5162887
```

```
model.CD[which.max(model.CD)]
```

```
##      2737
## 0.01154526
```

```
n = nrow(df)
p = m1$rank
plot(m1, which = 4)
abline(h=4/n,lty=2)
```



```
lm(AvgSexFreq ~ SmokeNow + AlcoholYear + RegularMarij + HardDrugs + Regular .
```

```
df[c(2737, 3315, 8155),]
```

```
## # A tibble: 3 x 78
```



```

## # BMI_CatUnder20yrs <fct>, BMI_WHO <fct>, Pulse <int>, BPSysAve <int>,
## # BPDiaAve <int>, BPSys1 <int>, BPDia1 <int>, BPSys2 <int>, BPDia2 <int>,
## # BPSys3 <int>, BPDia3 <int>, Testosterone <dbl>, DirectChol <dbl>,
## # TotChol <dbl>, UrineVol1 <int>, UrineFlow1 <dbl>, UrineVol2 <int>, ...
df2 = df[-c(3315),]
m2 = lm(AvgSexFreq ~ SmokeNow+AlcoholYear+RegularMarij+HardDrugs+RegularMarij*HardDrugs+Age+Gender+HHIncome+Education, data = df)
summary(m1)

##
## Call:
## lm(formula = AvgSexFreq ~ SmokeNow + AlcoholYear + RegularMarij +
##     HardDrugs + RegularMarij * HardDrugs + Age + Gender + HHIncome +
##     Education, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.97351 -0.57280  0.00155  0.58754  2.66593
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.4866093   0.2026882   -2.401  0.01646 *
## SmokeNowYes     -0.1226982   0.0457879   -2.680  0.00744 **
## AlcoholYear     -0.0008466   0.0002090   -4.051 5.33e-05 ***
## RegularMarijYes -0.4499456   0.0565859   -7.952 3.26e-15 ***
## HardDrugsYes    -0.6026914   0.0761115   -7.919 4.22e-15 ***
## Age              0.0495315   0.0019548  25.338 < 2e-16 ***
## Gendermale      -0.3373153   0.0437338   -7.713 2.04e-14 ***
## HHIncome 5000-9999 -0.5386945   0.1950816   -2.761  0.00582 **
## HHIncome10000-14999 -0.3560340   0.1656085   -2.150  0.03170 *
## HHIncome15000-19999 -0.1488586   0.1670012   -0.891  0.37286
## HHIncome20000-24999 -0.2047610   0.1626641   -1.259  0.20827
## HHIncome25000-34999 -0.0578691   0.1573318   -0.368  0.71305
## HHIncome35000-44999 -0.0974220   0.1613428   -0.604  0.54604
## HHIncome45000-54999 -0.0548363   0.1591968   -0.344  0.73054
## HHIncome55000-64999 -0.2137773   0.1627365   -1.314  0.18914
## HHIncome65000-74999  0.0757010   0.1663099    0.455  0.64904
## HHIncome75000-99999  0.0086152   0.1558027    0.055  0.95591
## HHIncome more 99999  0.0654338   0.1522073    0.430  0.66732
## Education9 - 11th Grade  0.0351823   0.1203788    0.292  0.77012
## EducationHigh School  0.0205410   0.1166196    0.176  0.86021
## EducationSome College -0.0062633   0.1156260   -0.054  0.95681
## EducationCollege Grad -0.0796581   0.1221844   -0.652  0.51452
## RegularMarijYes:HardDrugsYes 0.3197590   0.0973576    3.284  0.00104 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8875 on 1759 degrees of freedom
## (8193 observations deleted due to missingness)
## Multiple R-squared:  0.3868, Adjusted R-squared:  0.3791
## F-statistic: 50.43 on 22 and 1759 DF, p-value: < 2.2e-16
summary(m2)

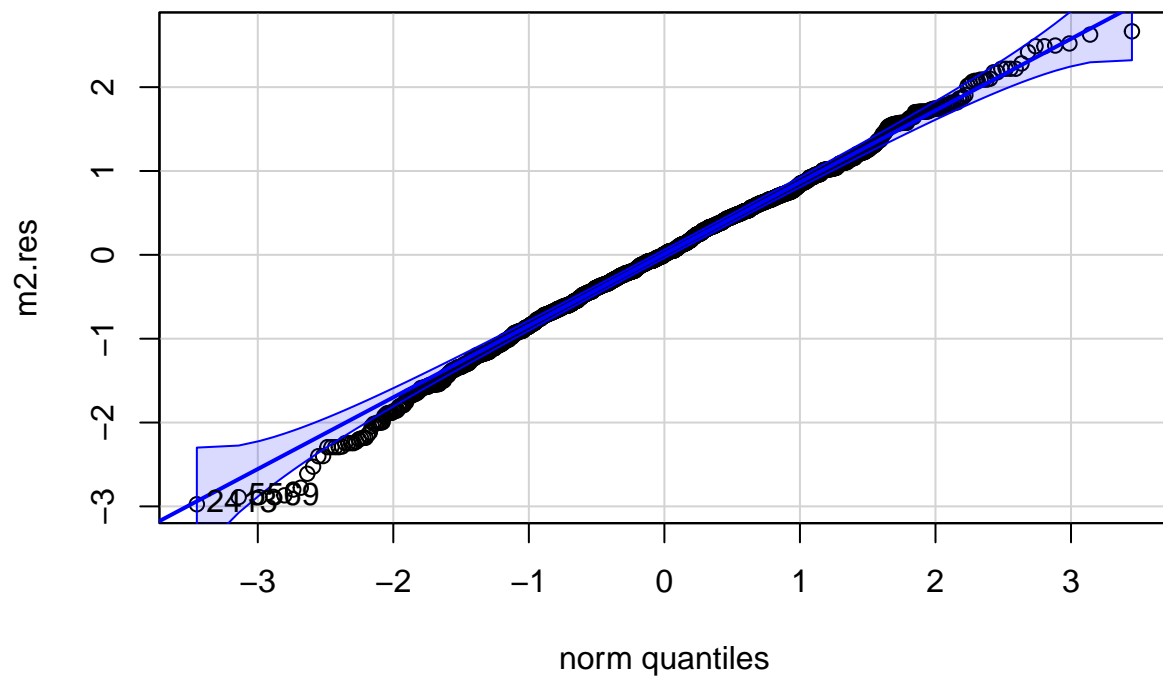
##

```

```
## Call:
## lm(formula = AvgSexFreq ~ SmokeNow + AlcoholYear + RegularMarij +
##     HardDrugs + RegularMarij * HardDrugs + Age + Gender + HHIncome +
##     Education, data = df2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.97442 -0.56586  0.00393  0.58777  2.66542
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.4504301   0.2025488   -2.224  0.026288 *
## SmokeNowYes     -0.1262317   0.0456933   -2.763  0.005794 **
## AlcoholYear     -0.0008394   0.0002085   -4.026  5.92e-05 ***
## RegularMarijYes -0.4526468   0.0564579   -8.017  1.95e-15 ***
## HardDrugsYes    -0.6072452   0.0759447   -7.996  2.31e-15 ***
## Age             0.0496820   0.0019508   25.467 < 2e-16 ***
## Gendermale     -0.3353620   0.0436343   -7.686  2.51e-14 ***
## HHIncome 5000-9999 -0.5415626   0.1946190   -2.783  0.005449 **
## HHIncome10000-14999 -0.3577768   0.1652149   -2.166  0.030482 *
## HHIncome15000-19999 -0.1516692   0.1666058   -0.910  0.362764
## HHIncome20000-24999 -0.2093735   0.1622834   -1.290  0.197161
## HHIncome25000-34999 -0.0462766   0.1570024   -0.295  0.768219
## HHIncome35000-44999 -0.1024180   0.1609666   -0.636  0.524684
## HHIncome45000-54999 -0.0578562   0.1588205   -0.364  0.715688
## HHIncome55000-64999 -0.2168239   0.1623518   -1.336  0.181880
## HHIncome65000-74999  0.0736871   0.1659149    0.444  0.657006
## HHIncome75000-99999  0.0059989   0.1554339    0.039  0.969218
## HHIncome more 99999  0.0627278   0.1518472    0.413  0.679585
## Education9 - 11th Grade -0.0029744   0.1207343   -0.025  0.980348
## EducationHigh School -0.0174155   0.1169977   -0.149  0.881686
## EducationSome College -0.0448210   0.1160331   -0.386  0.699338
## EducationCollege Grad -0.1192098   0.1225732   -0.973  0.330905
## RegularMarijYes:HardDrugsYes 0.3231571   0.0971319    3.327  0.000896 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8853 on 1758 degrees of freedom
## (8193 observations deleted due to missingness)
## Multiple R-squared:  0.3891, Adjusted R-squared:  0.3815
## F-statistic: 50.91 on 22 and 1758 DF, p-value: < 2.2e-16

m2.res = m2$residuals

car::qqPlot(m2.res)
```



```
## 2413 5569  
## 458 1029
```