STAT 331 Final Project

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Requirement of the project

Your 7–10 page report must contain the following components:

- 1. Summary: A maximum of 200 words describing the objective of the report, an overview of the statistical analysis, and summary of the main results.
- 2. Objective: Describe your goals for the analysis.
- 3. Exploratory Data Analysis: Conduct exploratory data analyses: report summary statistics, visualize data (histograms, scatter plots, etc.). Report on any interesting findings and comment on how these inform the rest of your analysis.
- 4. Methods: Describe your statistical analysis: What is your model? Did you use any transformations or extensions of the basic multiple linear regression model? How did you select a model? Does the model fit the data well? Are the necessary assumptions met? Be sure to explain and justify your decisions.
- 5. Results: Report on the findings of your analysis
- 6. Discussion: Comment on your findings/conclusions; describe any limitations of your analysis.

1. Summary

A maximum of 200 words describing the objective of the report, an overview of the statistical analysis, and summary of the main results.

2. Objective

The goal of this project is to analyze the pollutants.csv data and write a report on your analysis. The specific goals of your analysis are up to you to decide.

3. Exploratory Data Analysis

Conduct exploratory data analyses: report summary statistics, visualize data (histograms, scatter plots, etc.). Report on any interesting findings and comment on how these inform the rest of your analysis.

can use this as a tutorial https://r4ds.had.co.nz/exploratory-data-analysis.html

Take a peak at the first 5 entries

```
# CHANGE ABSOLUTE PATH
# setwd("~/Desktop/stat341/R331project/data")
setwd("~/School/4A/STAT 331/R331project/data")
# setwd("~/Desktop/R331project/data")
```

```r
# setwd("C:/Users/huawei/Desktop/R331project/data")

pollutants_raw <- read.csv("pollutants.csv", header = TRUE)
head(pollutants_raw)
```

```
##   X    length POP_PCB1 POP_PCB2 POP_PCB3 POP_PCB4 POP_PCB5 POP_PCB6 POP_PCB7
## 1 1 1.1587651    20000     7600     3700    14700    18900     5300     5500
## 2 2 0.9011283    43900    14900     9700    32300    55500    13400    18700
## 3 3 1.2753948     3300     3300     3300     3300     3300     3300     3300
## 4 4 0.9369063     8500     4100     6000    11500    13500     6900    13500
## 5 5 0.7027998   159000    60200    29800   170000   215000    79200    47400
## 6 6 1.1516147    14400     7100    16900    28200    37200    22000    10200
##   POP_PCB8 POP_PCB9 POP_PCB10 POP_PCB11 POP_dioxin1 POP_dioxin2 POP_dioxin3
## 1     5700     2000      15.6      23.1        70.9        50.0         173
## 2    12000    16200      35.4      31.1       116.0       129.0         709
## 3     3300     3300       1.8       9.3        29.9         5.4         148
## 4     4100     4100       4.5      21.1        50.4        29.4         668
## 5    41400    53900      59.2      80.3        98.1        80.1         875
## 6     3800     6400      19.2      70.0       106.0        47.4         533
##   POP_furan1 POP_furan2 POP_furan3 POP_furan4 whitecell_count lymphocyte_pct
## 1        6.9        5.6        0.8       15.6             5.4           33.8
## 2       18.5       15.4       20.3        2.3             5.6           16.8
## 3        1.3        1.4        1.2        2.9             6.3           35.3
## 4        2.2        2.4        2.3       43.2             8.4           23.0
## 5       13.7        1.2        0.8       11.0             6.7           24.5
## 6        8.3        7.0        3.4       19.4             4.7           39.5
##   monocyte_pct eosinophils_pct basophils_pct neutrophils_pct   BMI edu_cat
## 1          8.1            51.2           6.2             0.6 27.50       2
## 2         10.2            69.4           3.2             0.5 27.46       3
## 3          7.3            54.9           1.6             0.9 36.13       1
## 4          6.4            68.8           1.7             0.2 21.79       4
## 5          7.5            64.3           3.0             0.8 31.46       2
## 6          4.4            54.2           1.3             0.8 40.68       1
##   race_cat male ageyrs yrssmoke smokenow ln_lbxcot
## 1        4    1     41        0        0 -2.312635
## 2        4    0     77        0        0 -4.509860
## 3        2    0     22        0        0 -4.017384
## 4        4    0     27        0        0 -3.863233
## 5        4    1     78        0        0 -1.826351
## 6        3    0     35        0        0 -2.207275
```

```r
summary(pollutants_raw)
```

```
##        X             length          POP_PCB1          POP_PCB2     
##  Min.   :  1.0   Min.   :0.5266   Min.   :  2000   Min.   :  2000  
##  1st Qu.:216.8   1st Qu.:0.8754   1st Qu.:  9975   1st Qu.:  4800  
##  Median :432.5   Median :1.0286   Median : 27600   Median : 11500  
##  Mean   :432.5   Mean   :1.0543   Mean   : 38082   Mean   : 15637  
##  3rd Qu.:648.2   3rd Qu.:1.2095   3rd Qu.: 53325   3rd Qu.: 21825  
##  Max.   :864.0   Max.   :2.3512   Max.   :572000   Max.   :165000  
##     POP_PCB3          POP_PCB4          POP_PCB5          POP_PCB6     
##  Min.   :  2000   Min.   :  2100   Min.   :  2100   Min.   :  2000  
##  1st Qu.:  3700   1st Qu.: 11475   1st Qu.: 15600   1st Qu.:  4400  
##  Median :  6200   Median : 25550   Median : 36300   Median :  9400  
```

```
##  Mean   : 10158   Mean   : 38456   Mean   : 52650   Mean   : 16820
##  3rd Qu.: 12000   3rd Qu.: 50650   3rd Qu.: 68625   3rd Qu.: 19500
##  Max.   :123000   Max.   :487000   Max.   :708000   Max.   :319000
##     POP_PCB7         POP_PCB8         POP_PCB9        POP_PCB10
##  Min.   :  1100   Min.   :  1100   Min.   :  1100   Min.   :  1.70
##  1st Qu.:  4000   1st Qu.:  3800   1st Qu.:  3900   1st Qu.:  9.10
##  Median :  7450   Median :  6950   Median :  8050   Median : 18.35
##  Mean   : 12682   Mean   : 10530   Mean   : 12220   Mean   : 24.49
##  3rd Qu.: 15625   3rd Qu.: 14425   3rd Qu.: 16025   3rd Qu.: 34.90
##  Max.   :144000   Max.   :187000   Max.   :144000   Max.   :172.00
##    POP_PCB11       POP_dioxin1      POP_dioxin2      POP_dioxin3
##  Min.   :  1.30   Min.   :  1.90   Min.   :  1.40   Min.   :  36.8
##  1st Qu.: 14.80   1st Qu.: 23.90   1st Qu.: 21.27   1st Qu.: 197.0
##  Median : 24.50   Median : 41.35   Median : 37.80   Median : 342.5
##  Mean   : 38.15   Mean   : 57.65   Mean   : 47.81   Mean   : 494.4
##  3rd Qu.: 42.95   3rd Qu.: 71.62   3rd Qu.: 62.42   3rd Qu.: 603.0
##  Max.   :845.00   Max.   :760.00   Max.   :281.00   Max.   :8190.0
##    POP_furan1       POP_furan2       POP_furan3       POP_furan4
##  Min.   : 1.000   Min.   : 0.800   Min.   : 0.700   Min.   :  0.90
##  1st Qu.: 3.200   1st Qu.: 2.600   1st Qu.: 2.200   1st Qu.:  6.40
##  Median : 5.200   Median : 4.200   Median : 5.050   Median :  9.65
##  Mean   : 6.371   Mean   : 5.390   Mean   : 6.669   Mean   : 11.54
##  3rd Qu.: 7.700   3rd Qu.: 6.825   3rd Qu.: 9.300   3rd Qu.: 14.00
##  Max.   :44.400   Max.   :33.500   Max.   :38.300   Max.   :234.00
##  whitecell_count  lymphocyte_pct  monocyte_pct   eosinophils_pct
##  Min.   : 2.300   Min.   : 5.80   Min.   : 1.600   Min.   :21.60
##  1st Qu.: 5.600   1st Qu.:24.00   1st Qu.: 6.600   1st Qu.:52.35
##  Median : 6.900   Median :28.95   Median : 7.700   Median :59.30
##  Mean   : 7.191   Mean   :29.92   Mean   : 7.936   Mean   :58.62
##  3rd Qu.: 8.300   3rd Qu.:35.42   3rd Qu.: 9.100   3rd Qu.:65.22
##  Max.   :20.100   Max.   :73.40   Max.   :23.800   Max.   :88.10
##  basophils_pct    neutrophils_pct      BMI            edu_cat
##  Min.   : 0.000   Min.   :0.0000   Min.   :16.16   Min.   :1.000
##  1st Qu.: 1.500   1st Qu.:0.4000   1st Qu.:23.88   1st Qu.:1.000
##  Median : 2.300   Median :0.6000   Median :27.38   Median :2.000
##  Mean   : 2.903   Mean   :0.6669   Mean   :28.09   Mean   :2.338
##  3rd Qu.: 3.700   3rd Qu.:0.8000   3rd Qu.:31.17   3rd Qu.:3.000
##  Max.   :28.200   Max.   :5.5000   Max.   :62.99   Max.   :4.000
##     race_cat          male            ageyrs         yrssmoke
##  Min.   :1.000   Min.   :0.0000   Min.   :20.00   Min.   : 0.0
##  1st Qu.:2.000   1st Qu.:0.0000   1st Qu.:34.00   1st Qu.: 0.0
##  Median :4.000   Median :0.0000   Median :46.00   Median : 0.0
##  Mean   :3.133   Mean   :0.4329   Mean   :48.36   Mean   :10.6
##  3rd Qu.:4.000   3rd Qu.:1.0000   3rd Qu.:63.00   3rd Qu.:20.0
##  Max.   :4.000   Max.   :1.0000   Max.   :85.00   Max.   :69.0
##     smokenow        ln_lbxcot
##  Min.   :0.0000   Min.   :-4.5099
##  1st Qu.:0.0000   1st Qu.:-4.0745
##  Median :0.0000   Median :-2.7334
##  Mean   :0.2315   Mean   :-0.9804
##  3rd Qu.:0.0000   3rd Qu.: 2.8000
##  Max.   :1.0000   Max.   : 6.5848
```

```r
# Mxn's work
# clean the pollutants dataframe
pollutants <- subset(pollutants_raw , select = -X)

# deal with categorical data

# 1 = Less Than 9th Grade or 9-11th Grade (Includes 12th grade with no diploma)
# 2 = High School Grad/GED or Equivalent
# 3 = Some College or AA degree
# 4 = College Graduate
edu_factor=factor(pollutants$edu_cat)

# 1 = Other Race (Including Multi-Racial);
# 2 = Mexican American;
# 3 = Non-Hispanic Black;
# 4 = Non-Hispanic White
race_factor=factor(pollutants$race_cat,
                   labels = c("Other", "Mexican", "Black", "White"))

# 0 = does not currently smoke;
# 1 = currently smokes
smoke_factor=factor(pollutants$smokenow, labels = c("Non-Smoker", "Smoker"))

# 0 = female, 1 = male
gender_factor=factor(pollutants$male, labels = c("female", "male"))


pollutants$edu_cat = edu_factor
pollutants$race_cat = race_factor
pollutants$smokenow = smoke_factor
pollutants$male = gender_factor

head(pollutants)
```

```
##      length POP_PCB1 POP_PCB2 POP_PCB3 POP_PCB4 POP_PCB5 POP_PCB6 POP_PCB7
## 1 1.1587651    20000     7600     3700    14700    18900     5300     5500
## 2 0.9011283    43900    14900     9700    32300    55500    13400    18700
## 3 1.2753948     3300     3300     3300     3300     3300     3300     3300
## 4 0.9369063     8500     4100     6000    11500    13500     6900    13500
## 5 0.7027998   159000    60200    29800   170000   215000    79200    47400
## 6 1.1516147    14400     7100    16900    28200    37200    22000    10200
##   POP_PCB8 POP_PCB9 POP_PCB10 POP_PCB11 POP_dioxin1 POP_dioxin2 POP_dioxin3
## 1     5700     2000      15.6      23.1        70.9        50.0         173
## 2    12000    16200      35.4      31.1       116.0       129.0         709
## 3     3300     3300       1.8       9.3        29.9         5.4         148
## 4     4100     4100       4.5      21.1        50.4        29.4         668
## 5    41400    53900      59.2      80.3        98.1        80.1         875
## 6     3800     6400      19.2      70.0       106.0        47.4         533
##   POP_furan1 POP_furan2 POP_furan3 POP_furan4 whitecell_count lymphocyte_pct
## 1        6.9        5.6        0.8       15.6             5.4           33.8
## 2       18.5       15.4       20.3        2.3             5.6           16.8
## 3        1.3        1.4        1.2        2.9             6.3           35.3
## 4        2.2        2.4        2.3       43.2             8.4           23.0
## 5       13.7        1.2        0.8       11.0             6.7           24.5
```

```
## 6        8.3        7.0        3.4       19.4             4.7           39.5
##   monocyte_pct eosinophils_pct basophils_pct neutrophils_pct   BMI edu_cat
## 1          8.1            51.2           6.2             0.6 27.50       2
## 2         10.2            69.4           3.2             0.5 27.46       3
## 3          7.3            54.9           1.6             0.9 36.13       1
## 4          6.4            68.8           1.7             0.2 21.79       4
## 5          7.5            64.3           3.0             0.8 31.46       2
## 6          4.4            54.2           1.3             0.8 40.68       1
##   race_cat   male ageyrs yrssmoke   smokenow ln_lbxcot
## 1    White   male     41        0 Non-Smoker -2.312635
## 2    White female     77        0 Non-Smoker -4.509860
## 3  Mexican female     22        0 Non-Smoker -4.017384
## 4    White female     27        0 Non-Smoker -3.863233
## 5    White   male     78        0 Non-Smoker -1.826351
## 6    Black female     35        0 Non-Smoker -2.207275
```

```
summary(pollutants)
```

```
##      length          POP_PCB1         POP_PCB2         POP_PCB3     
##  Min.   :0.5266   Min.   :  2000   Min.   :  2000   Min.   :  2000  
##  1st Qu.:0.8754   1st Qu.:  9975   1st Qu.:  4800   1st Qu.:  3700  
##  Median :1.0286   Median : 27600   Median : 11500   Median :  6200  
##  Mean   :1.0543   Mean   : 38082   Mean   : 15637   Mean   : 10158  
##  3rd Qu.:1.2095   3rd Qu.: 53325   3rd Qu.: 21825   3rd Qu.: 12000  
##  Max.   :2.3512   Max.   :572000   Max.   :165000   Max.   :123000  
##     POP_PCB4         POP_PCB5         POP_PCB6         POP_PCB7     
##  Min.   :  2100   Min.   :  2100   Min.   :  2000   Min.   :  1100  
##  1st Qu.: 11475   1st Qu.: 15600   1st Qu.:  4400   1st Qu.:  4000  
##  Median : 25550   Median : 36300   Median :  9400   Median :  7450  
##  Mean   : 38456   Mean   : 52650   Mean   : 16820   Mean   : 12682  
##  3rd Qu.: 50650   3rd Qu.: 68625   3rd Qu.: 19500   3rd Qu.: 15625  
##  Max.   :487000   Max.   :708000   Max.   :319000   Max.   :144000  
##     POP_PCB8         POP_PCB9        POP_PCB10        POP_PCB11     
##  Min.   :  1100   Min.   :  1100   Min.   :  1.70   Min.   :  1.30  
##  1st Qu.:  3800   1st Qu.:  3900   1st Qu.:  9.10   1st Qu.: 14.80  
##  Median :  6950   Median :  8050   Median : 18.35   Median : 24.50  
##  Mean   : 10530   Mean   : 12220   Mean   : 24.49   Mean   : 38.15  
##  3rd Qu.: 14425   3rd Qu.: 16025   3rd Qu.: 34.90   3rd Qu.: 42.95  
##  Max.   :187000   Max.   :144000   Max.   :172.00   Max.   :845.00  
##   POP_dioxin1      POP_dioxin2      POP_dioxin3       POP_furan1    
##  Min.   :  1.90   Min.   :  1.40   Min.   :  36.8   Min.   : 1.000  
##  1st Qu.: 23.90   1st Qu.: 21.27   1st Qu.: 197.0   1st Qu.: 3.200  
##  Median : 41.35   Median : 37.80   Median : 342.5   Median : 5.200  
##  Mean   : 57.65   Mean   : 47.81   Mean   : 494.4   Mean   : 6.371  
##  3rd Qu.: 71.62   3rd Qu.: 62.42   3rd Qu.: 603.0   3rd Qu.: 7.700  
##  Max.   :760.00   Max.   :281.00   Max.   :8190.0   Max.   :44.400  
##    POP_furan2       POP_furan3       POP_furan4     whitecell_count 
##  Min.   : 0.800   Min.   : 0.700   Min.   :  0.90   Min.   : 2.300  
##  1st Qu.: 2.600   1st Qu.: 2.200   1st Qu.:  6.40   1st Qu.: 5.600  
##  Median : 4.200   Median : 5.050   Median :  9.65   Median : 6.900  
##  Mean   : 5.390   Mean   : 6.669   Mean   : 11.54   Mean   : 7.191  
##  3rd Qu.: 6.825   3rd Qu.: 9.300   3rd Qu.: 14.00   3rd Qu.: 8.300  
##  Max.   :33.500   Max.   :38.300   Max.   :234.00   Max.   :20.100  
##  lymphocyte_pct   monocyte_pct    eosinophils_pct basophils_pct  
##  Min.   : 5.80   Min.   : 1.600   Min.   :21.60   Min.   : 0.000  
```

```
##  1st Qu.:24.00   1st Qu.: 6.600   1st Qu.:52.35   1st Qu.: 1.500
##  Median :28.95   Median : 7.700   Median :59.30   Median : 2.300
##  Mean   :29.92   Mean   : 7.936   Mean   :58.62   Mean   : 2.903
##  3rd Qu.:35.42   3rd Qu.: 9.100   3rd Qu.:65.22   3rd Qu.: 3.700
##  Max.   :73.40   Max.   :23.800   Max.   :88.10   Max.   :28.200
##  neutrophils_pct       BMI        edu_cat    race_cat       male
##  Min.   :0.0000   Min.   :16.16   1:270   Other  : 71   female:490
##  1st Qu.:0.4000   1st Qu.:23.88   2:199   Mexican:191   male  :374
##  Median :0.6000   Median :27.38   3:228   Black  :154
##  Mean   :0.6669   Mean   :28.09   4:167   White  :448
##  3rd Qu.:0.8000   3rd Qu.:31.17
##  Max.   :5.5000   Max.   :62.99
##      ageyrs         yrssmoke         smokenow      ln_lbxcot
##  Min.   :20.00   Min.   : 0.0   Non-Smoker:664   Min.   :-4.5099
##  1st Qu.:34.00   1st Qu.: 0.0   Smoker    :200   1st Qu.:-4.0745
##  Median :46.00   Median : 0.0                    Median :-2.7334
##  Mean   :48.36   Mean   :10.6                    Mean   :-0.9804
##  3rd Qu.:63.00   3rd Qu.:20.0                    3rd Qu.: 2.8000
##  Max.   :85.00   Max.   :69.0                    Max.   : 6.5848
```

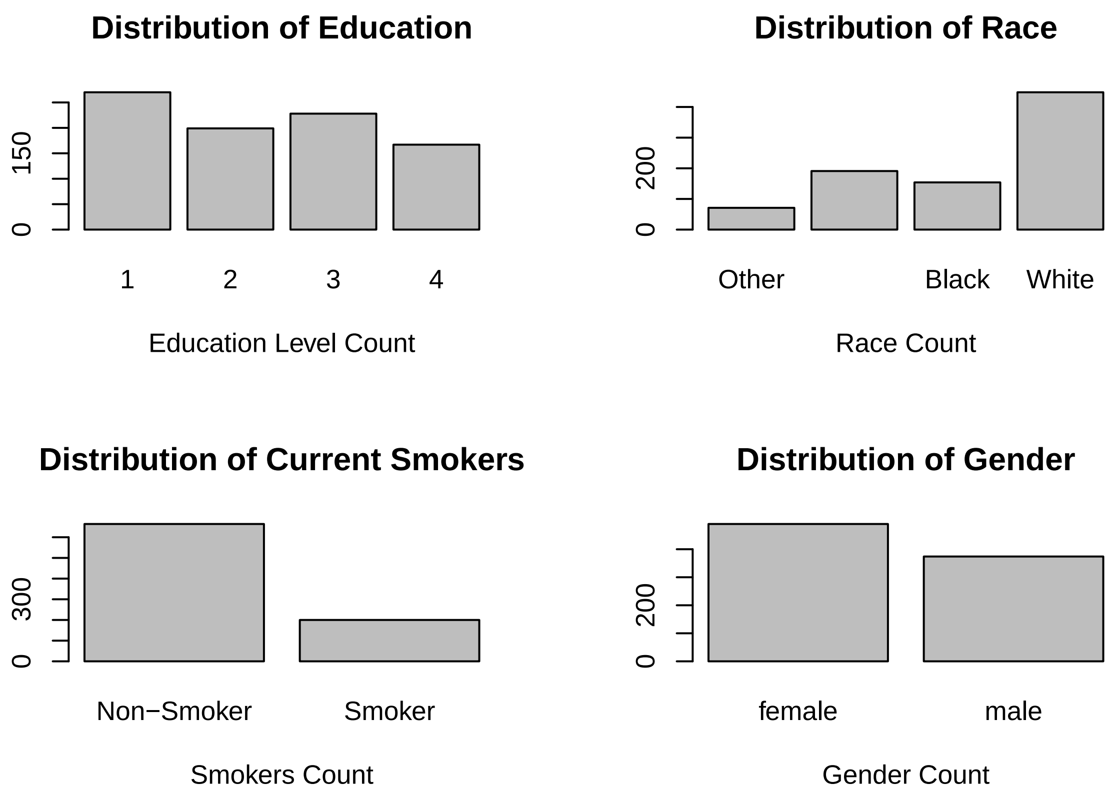
Get the names of Covariates

```
names(pollutants)
```

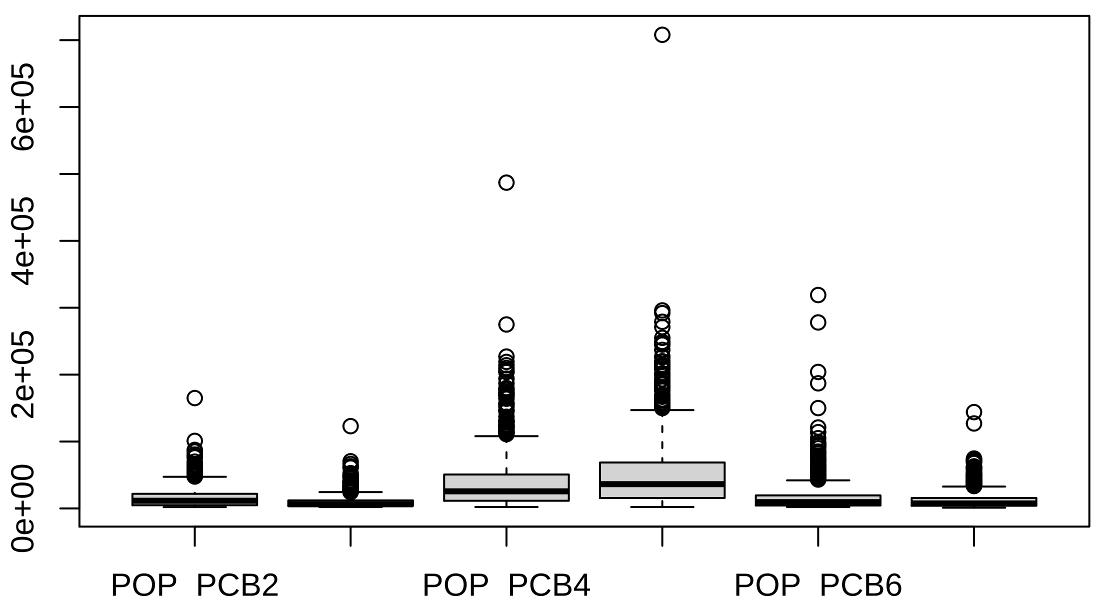
```
##  [1] "length"          "POP_PCB1"        "POP_PCB2"        "POP_PCB3"
##  [5] "POP_PCB4"        "POP_PCB5"        "POP_PCB6"        "POP_PCB7"
##  [9] "POP_PCB8"        "POP_PCB9"        "POP_PCB10"       "POP_PCB11"
## [13] "POP_dioxin1"     "POP_dioxin2"     "POP_dioxin3"     "POP_furan1"
## [17] "POP_furan2"      "POP_furan3"      "POP_furan4"      "whitecell_count"
## [21] "lymphocyte_pct"  "monocyte_pct"    "eosinophils_pct" "basophils_pct"
## [25] "neutrophils_pct" "BMI"             "edu_cat"         "race_cat"
## [29] "male"            "ageyrs"          "yrssmoke"        "smokenow"
## [33] "ln_lbxcot"
```

Note that "edu_cat", "race_cat", "male", "smokenow" are categorical data.

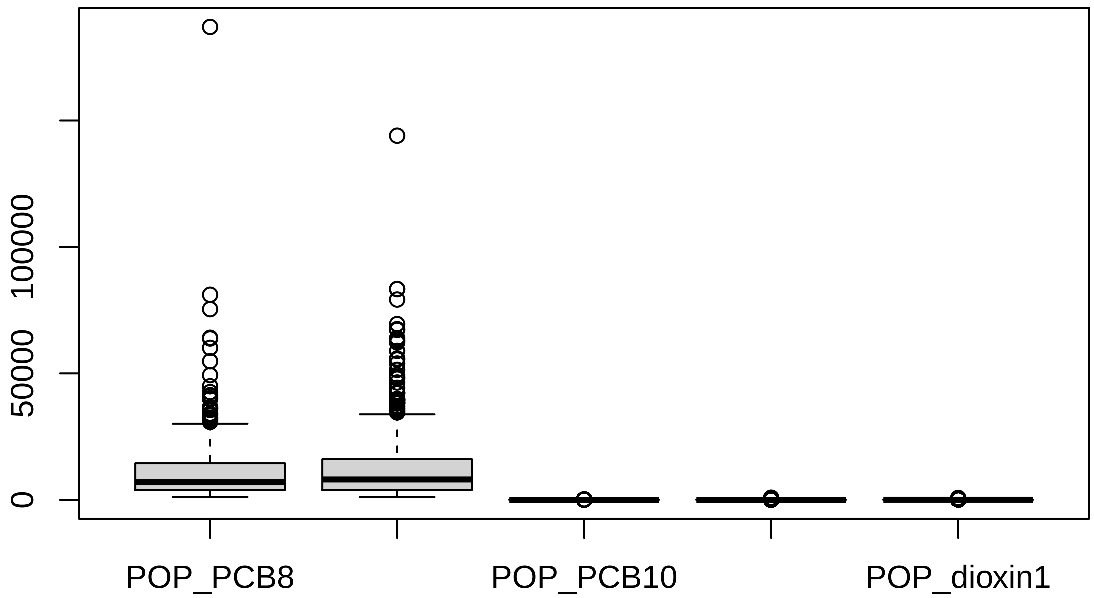
```
# Mxn's work
# put bargraphs for categorical data onto one picture
par(mfrow=c(2,2))

plot(edu_factor,
     main="Distribution of Education",
     xlab="Education Level Count")

plot(race_factor,
     main="Distribution of Race",
     xlab="Race Count")

plot(smoke_factor,
     main="Distribution of Current Smokers",
     xlab="Smokers Count")

plot(gender_factor,
     main="Distribution of Gender",
     xlab="Gender Count")
```



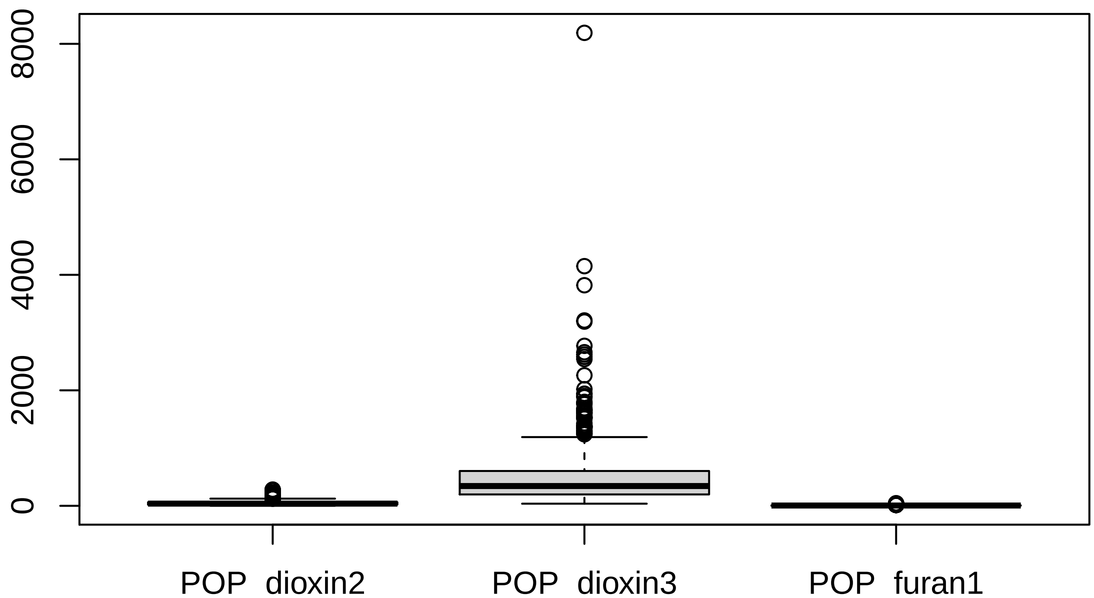

```r
# Man's work

# PC 1-6
boxplot(pollutants[, 3:8])
```



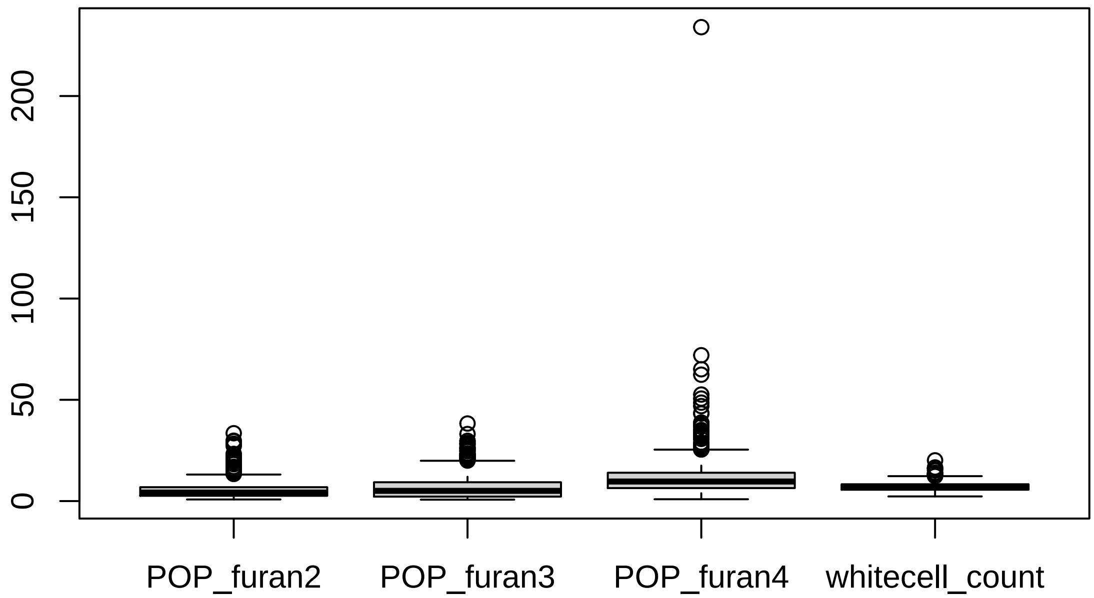

```r
# PC 7-11
boxplot(pollutants[, 9:13])
```




```
# Doxin
boxplot(pollutants[, 14:16])
```

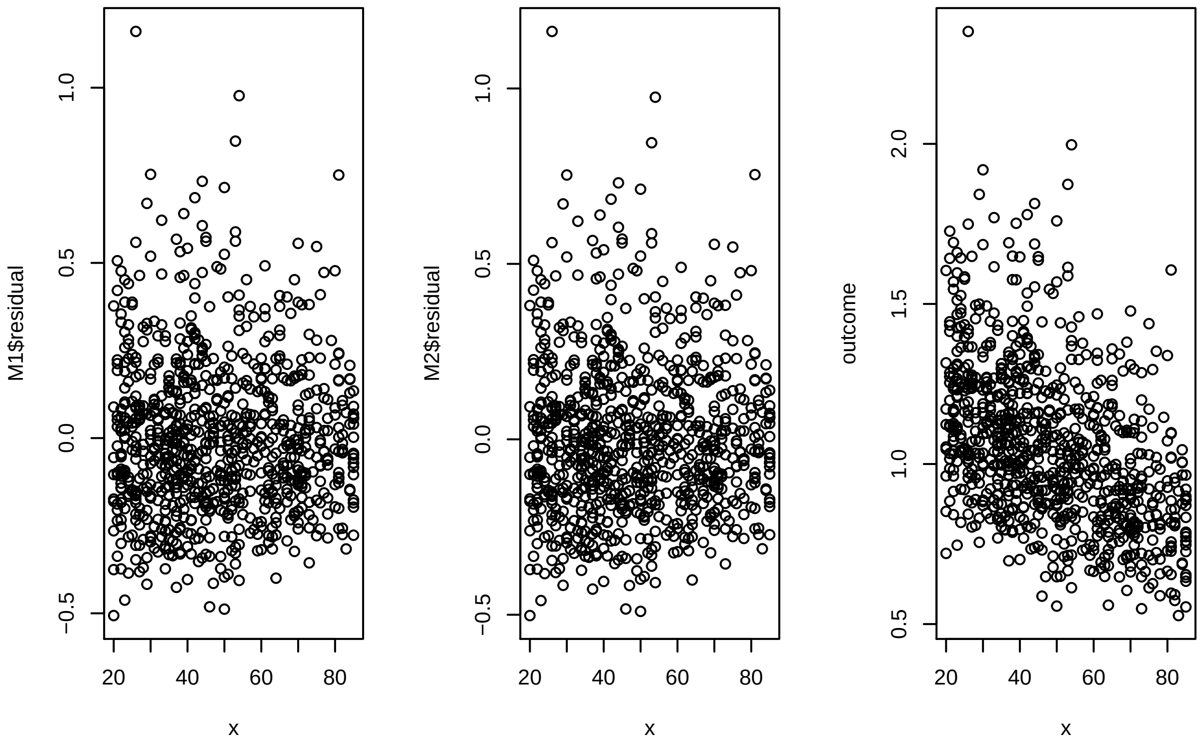



```
# Furan
boxplot(pollutants[, 17:20])
```

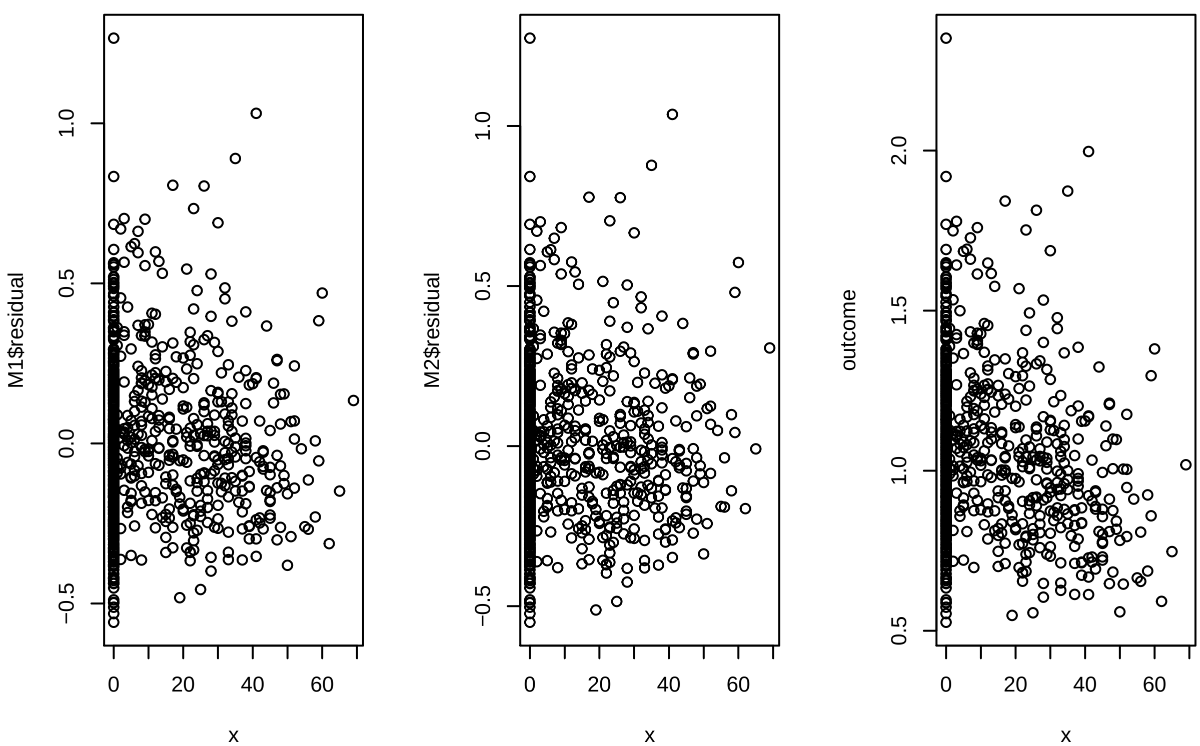



```r
# Judy's work Part 1
# testing non-linearity in SLR
# if for any covariate, residual vs x for M1 has a pattern and
# residual vs x for M2 seems random, then y has a nonlinear
# relationship with with x.
# M1: fitting y to x
# M2: fitting y to x^2

par(mfrow=c(1, 3))
outcome <- pollutants$length
check <- function(x) {
  M1 <- lm(outcome ~ x)
  print(paste("residual for M1: ", sigma(M1)))
  M2 <- lm(outcome ~ x + I(x^2))
  print(paste("residual for M2: ", sigma(M2)))
  plot(x, M1$residual)
  plot(x, M2$residual)
  plot(x, outcome)
}

list <- list(pollutants$ageyrs, pollutants$yrssmoke,
             pollutants$BMI, pollutants$ln_lbxcot,
             pollutants$whitecell_count, pollutants$lymphocyte_pct,
             pollutants$monocyte_pct, pollutants$eosinophils_pct,
             pollutants$basophils_pct, pollutants$neutrophils_pct)
for (column in list) {
  check(column)
}
```

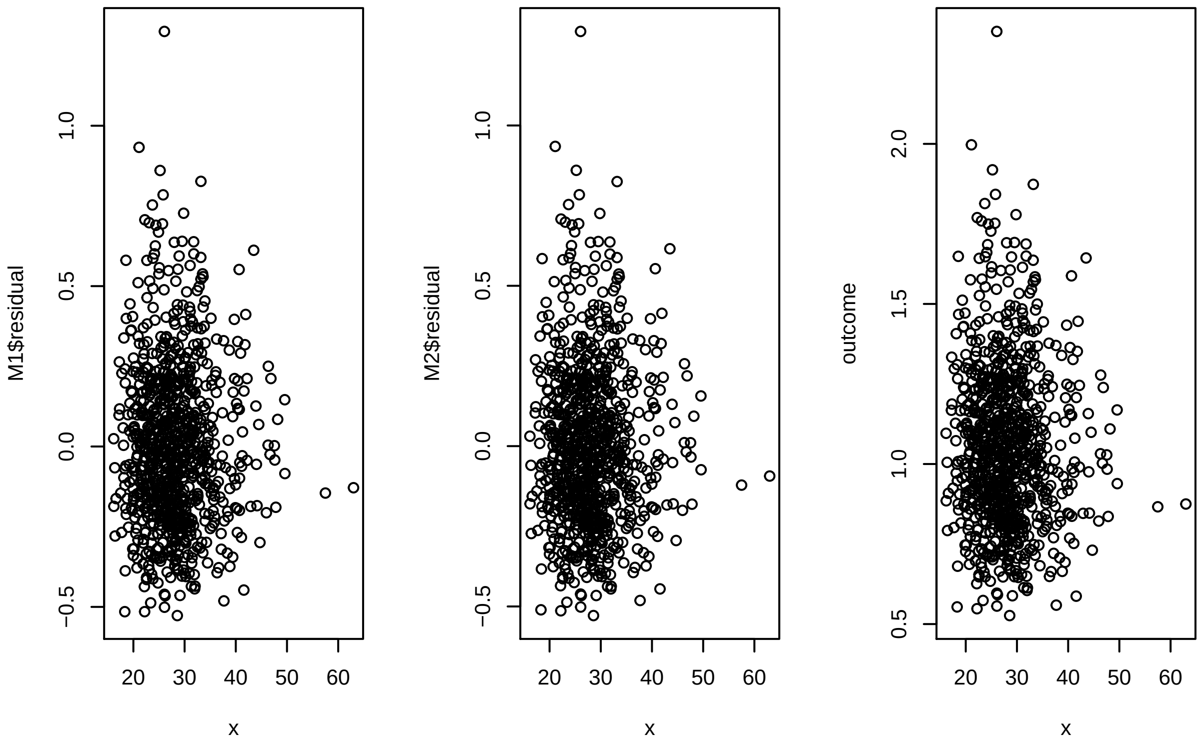
```
## [1] "residual for M1:  0.224172364185412"
## [1] "residual for M2:  0.22429269961392"
```



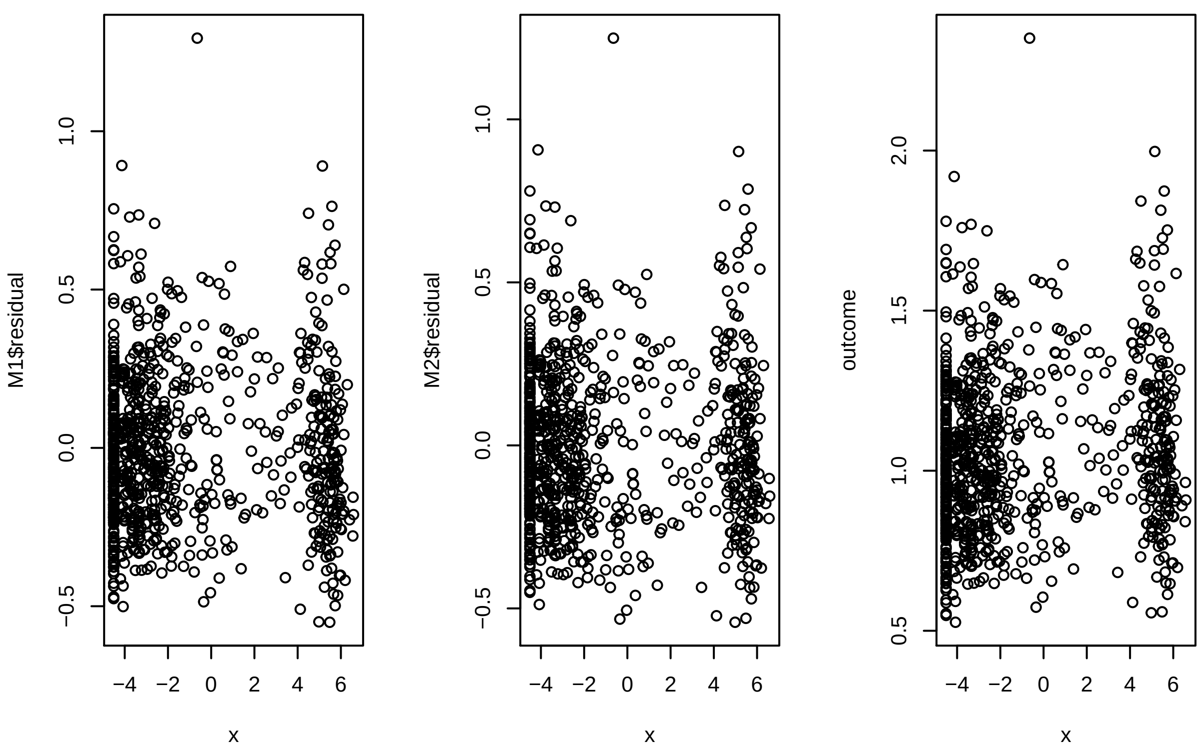

```
## [1] "residual for M1:  0.246320733146214"
## [1] "residual for M2:  0.245622720856213"
```



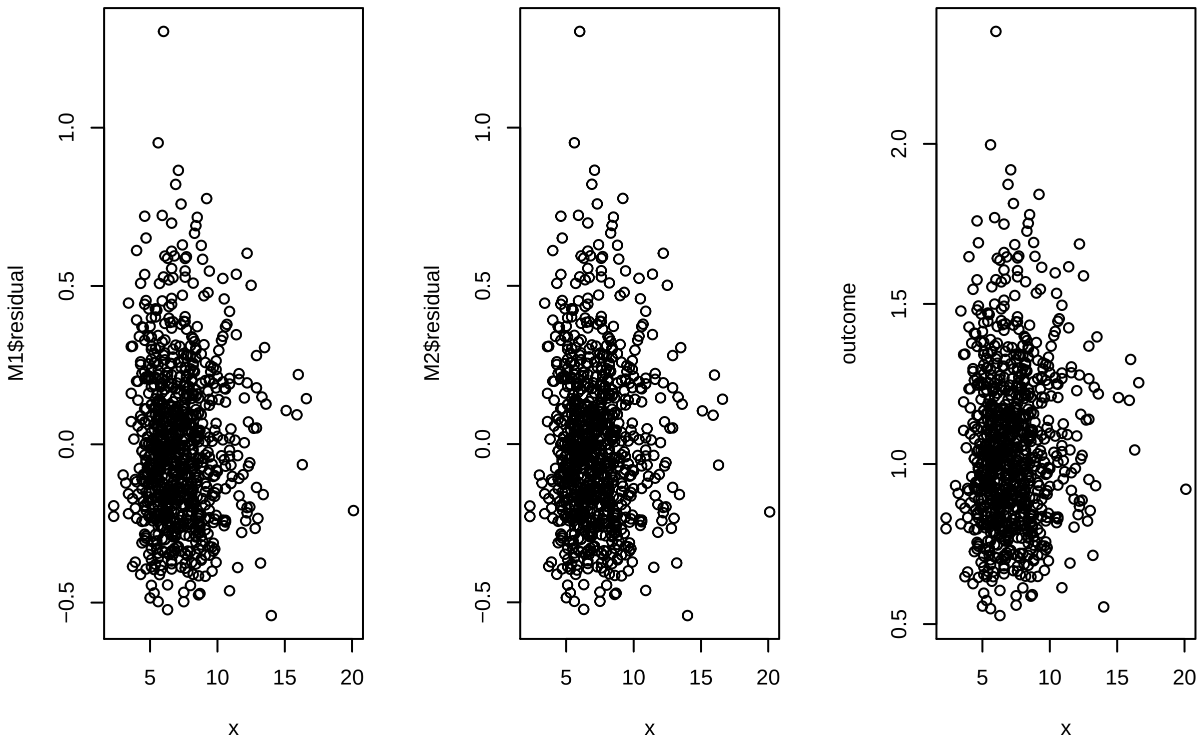

```
## [1] "residual for M1:  0.250228706427173"
## [1] "residual for M2:  0.25036248052387"
```



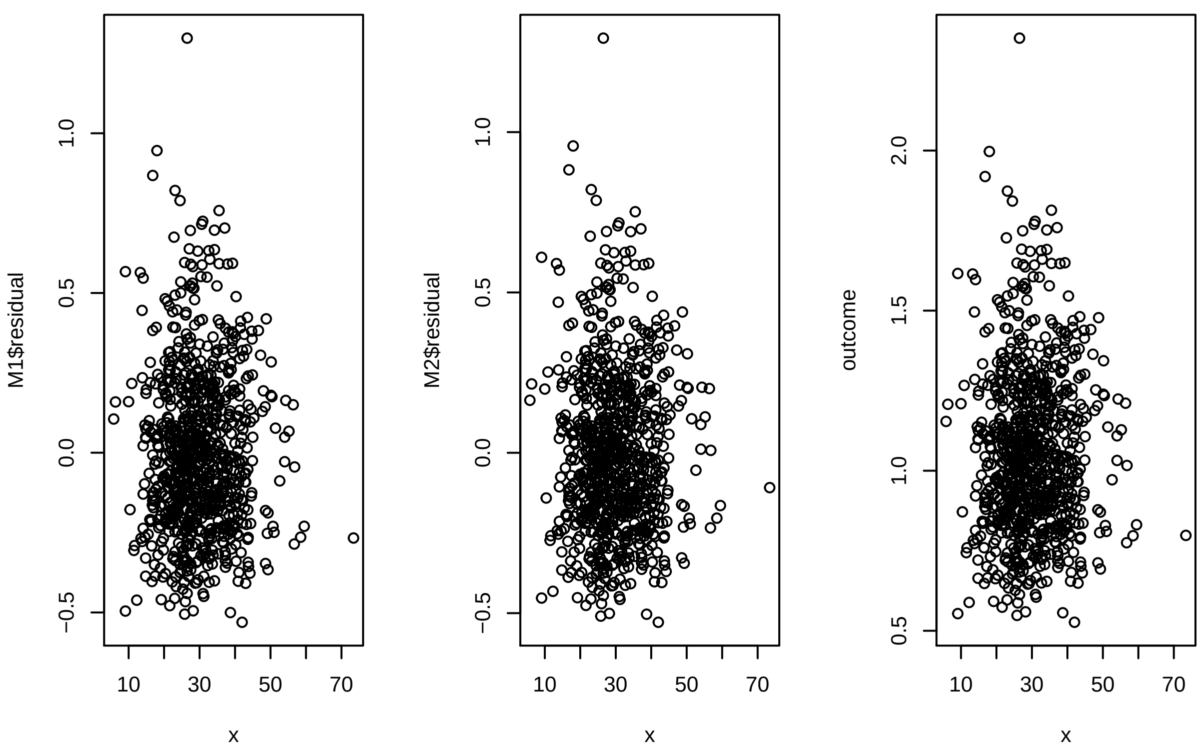

```
## [1] "residual for M1:  0.248212063673837"
## [1] "residual for M2:  0.24710732733351"
```



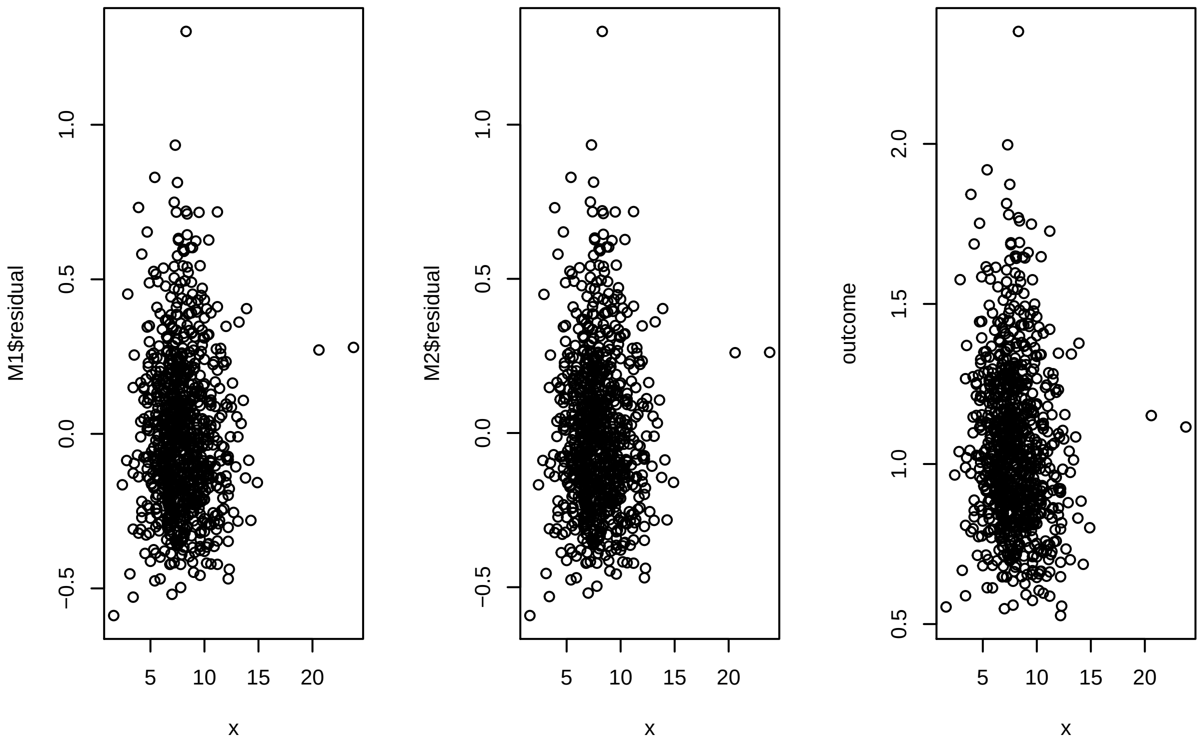

```
## [1] "residual for M1:  0.250065445847753"
## [1] "residual for M2:  0.250210403543218"
```



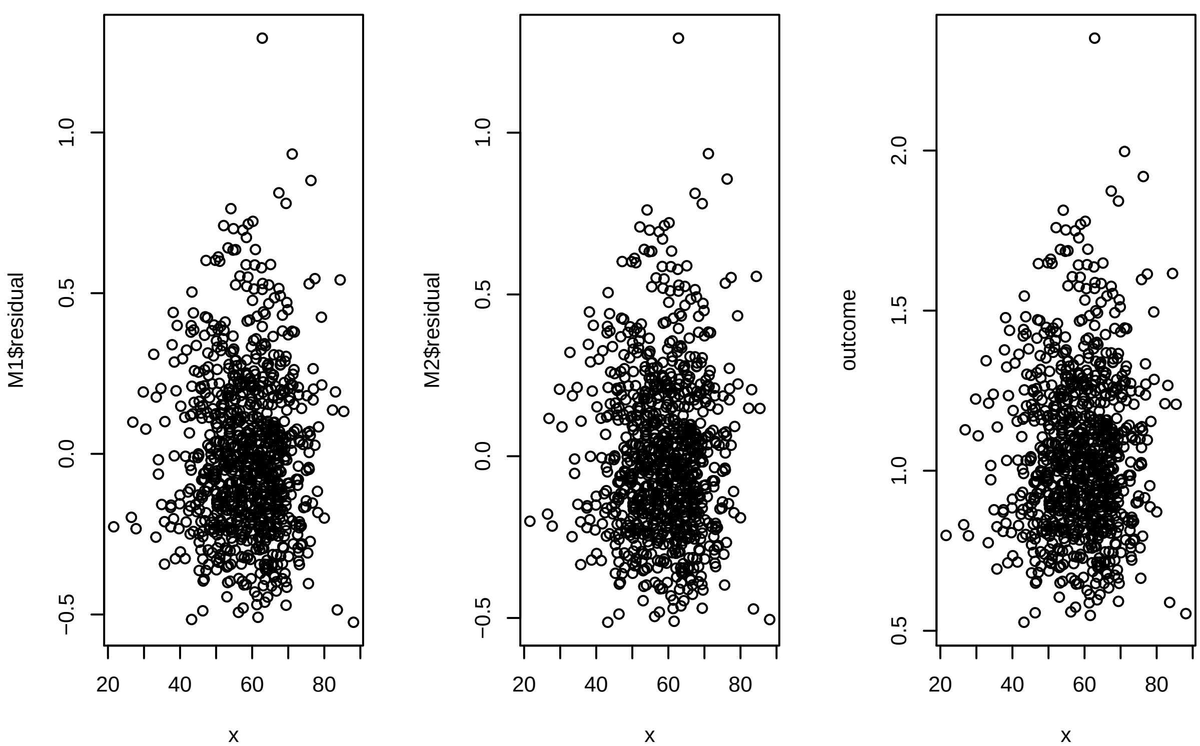

```
## [1] "residual for M1:  0.250373616826691"
## [1] "residual for M2:  0.250255208638358"
```



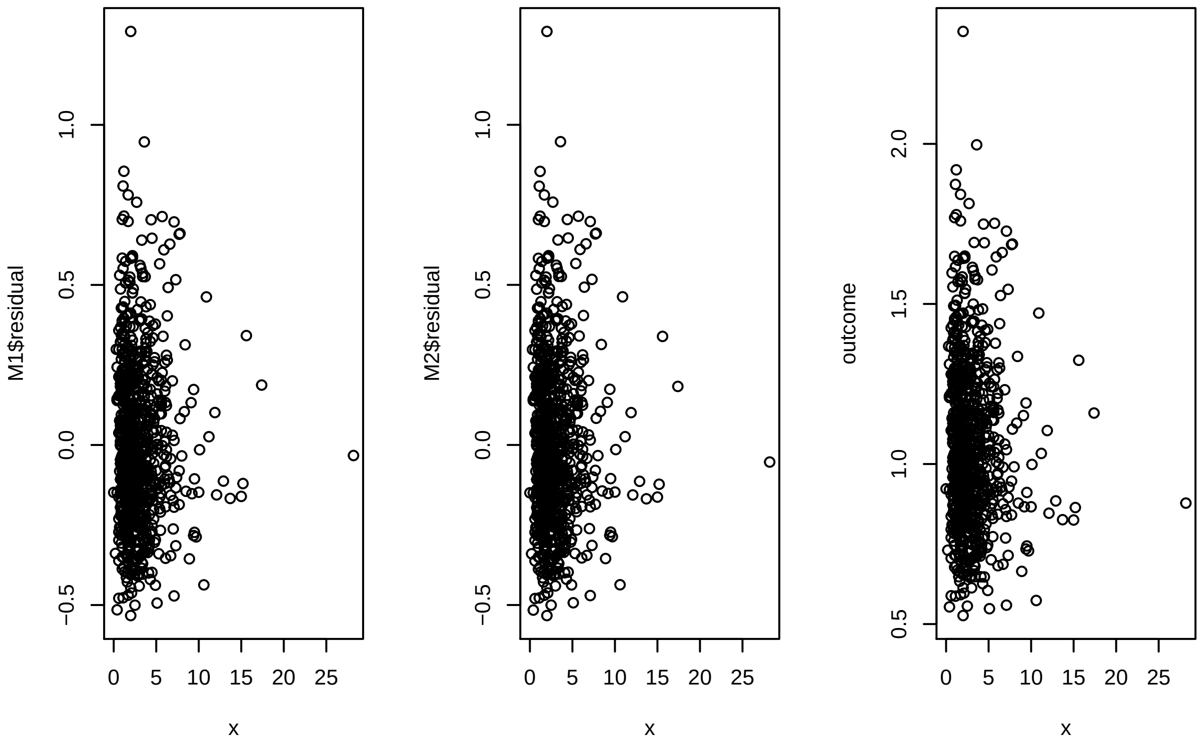

```
## [1] "residual for M1:  0.248704466454944"
## [1] "residual for M2:  0.248847192837983"
```



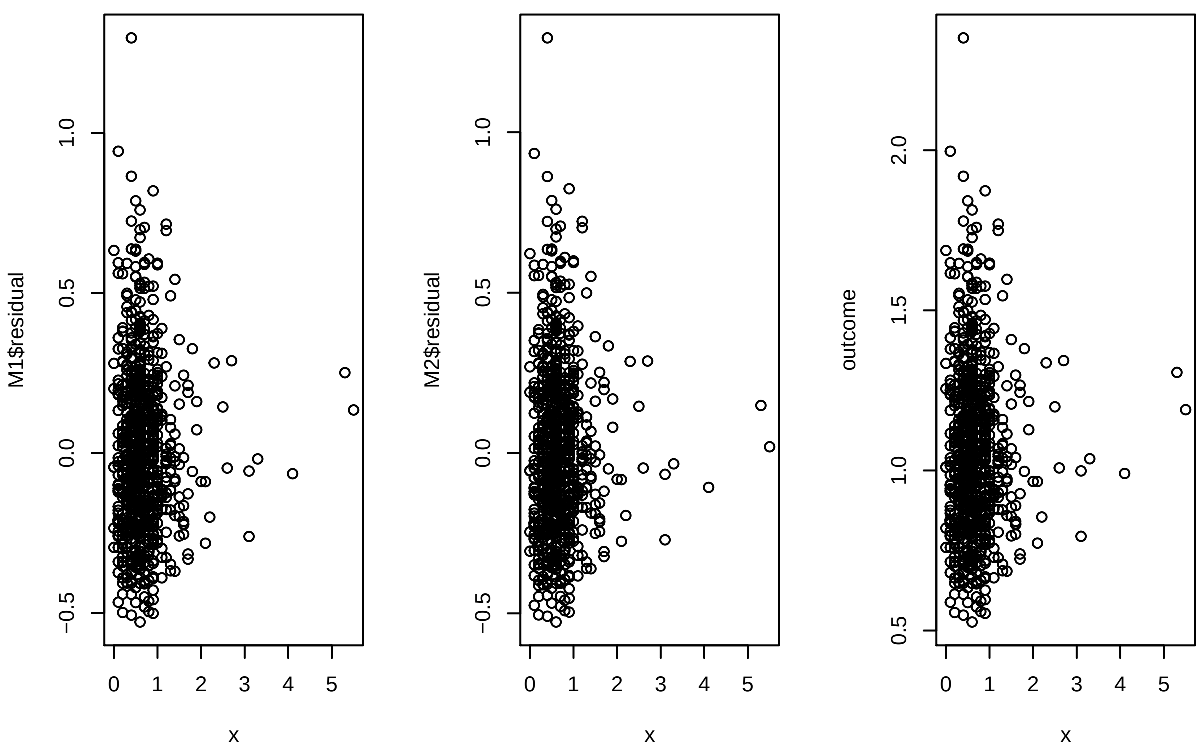

```
## [1] "residual for M1:  0.25026710930793"
## [1] "residual for M2:  0.250393729526099"
```




```
## [1] "residual for M1:  0.250043388210667"
## [1] "residual for M2:  0.25018695270193"
```



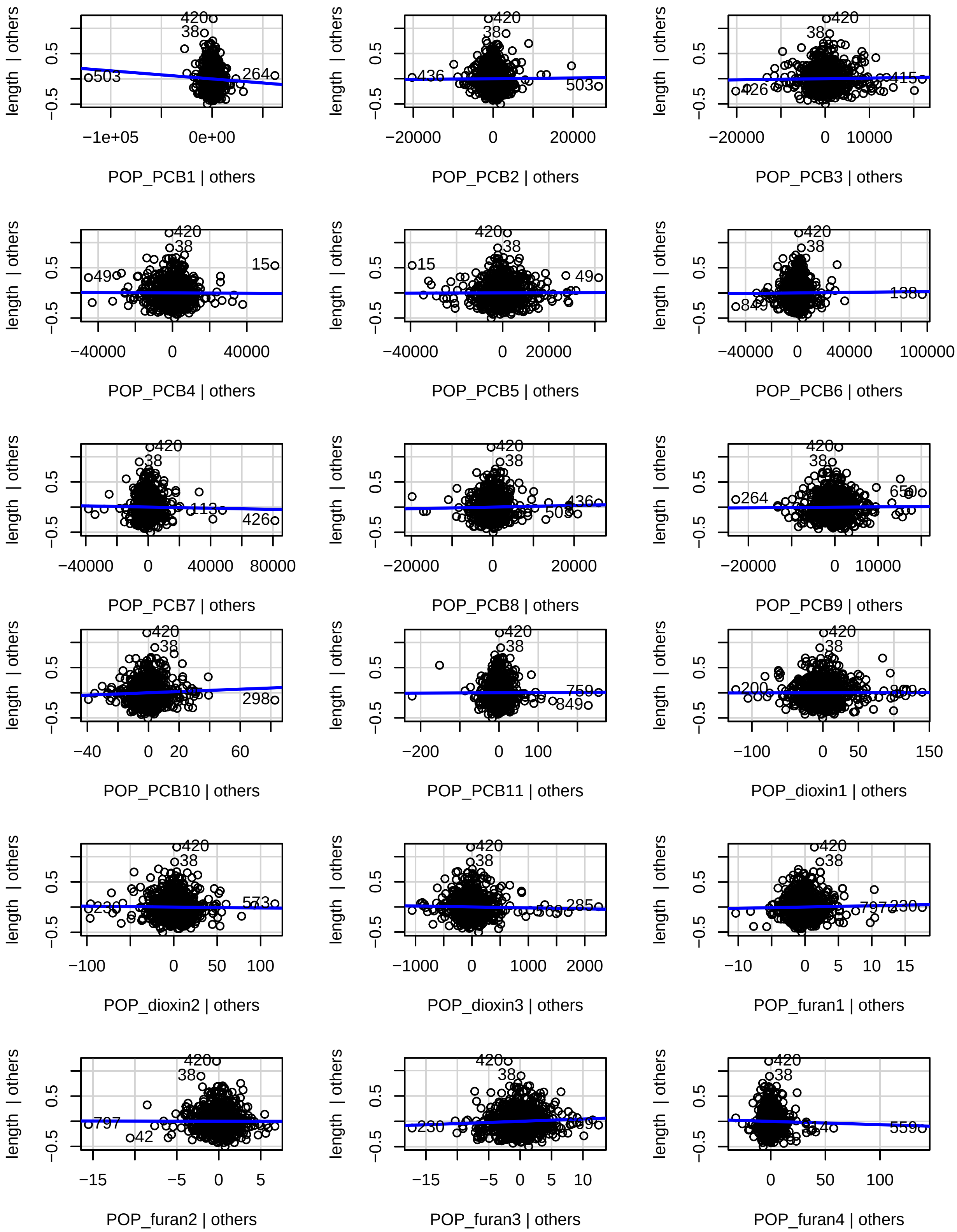

```
## [1] "residual for M1:  0.250382476371691"
## [1] "residual for M2:  0.25042580861039"
```

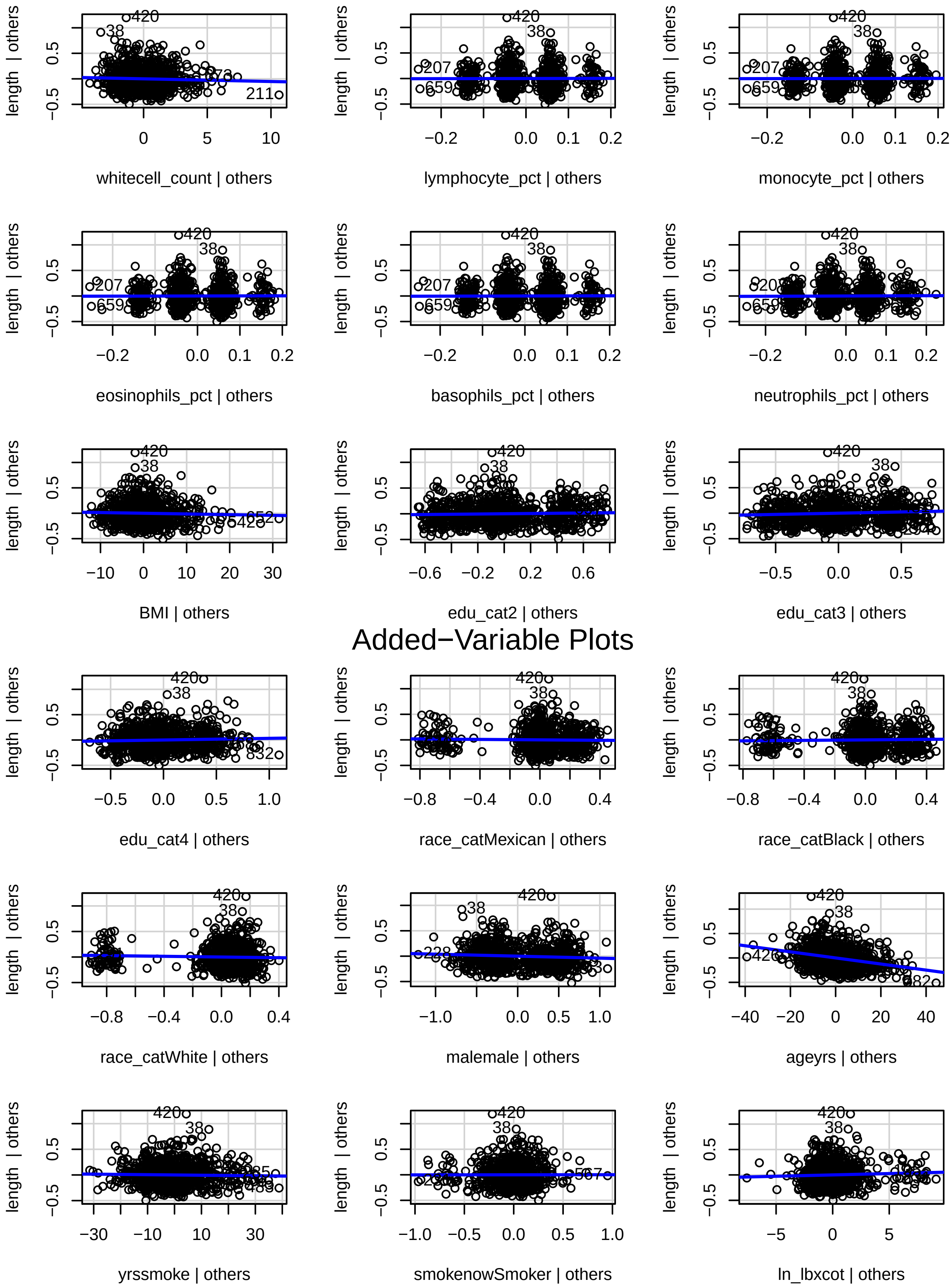



```
# Judy's work Part 2
# testing non-linearity in MLR
library(car)
```

```
## Loading required package: carData
```

```
M <- lm (length ~ ., data=pollutants)
avPlots(M)
```

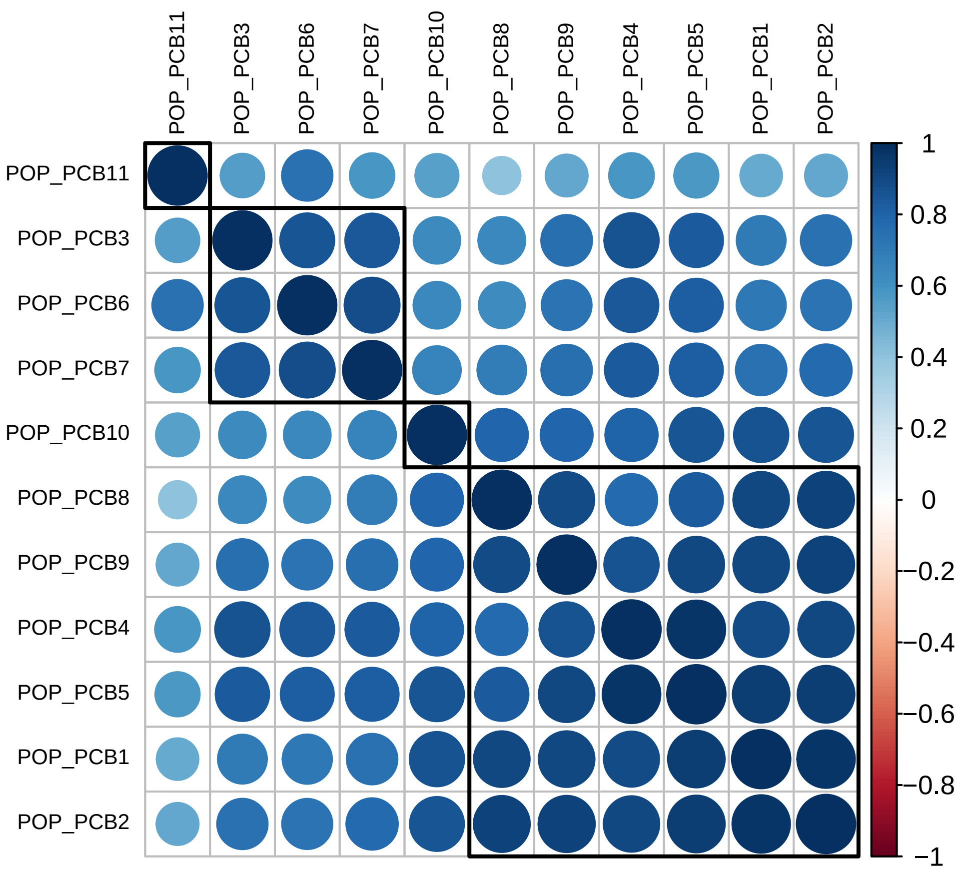




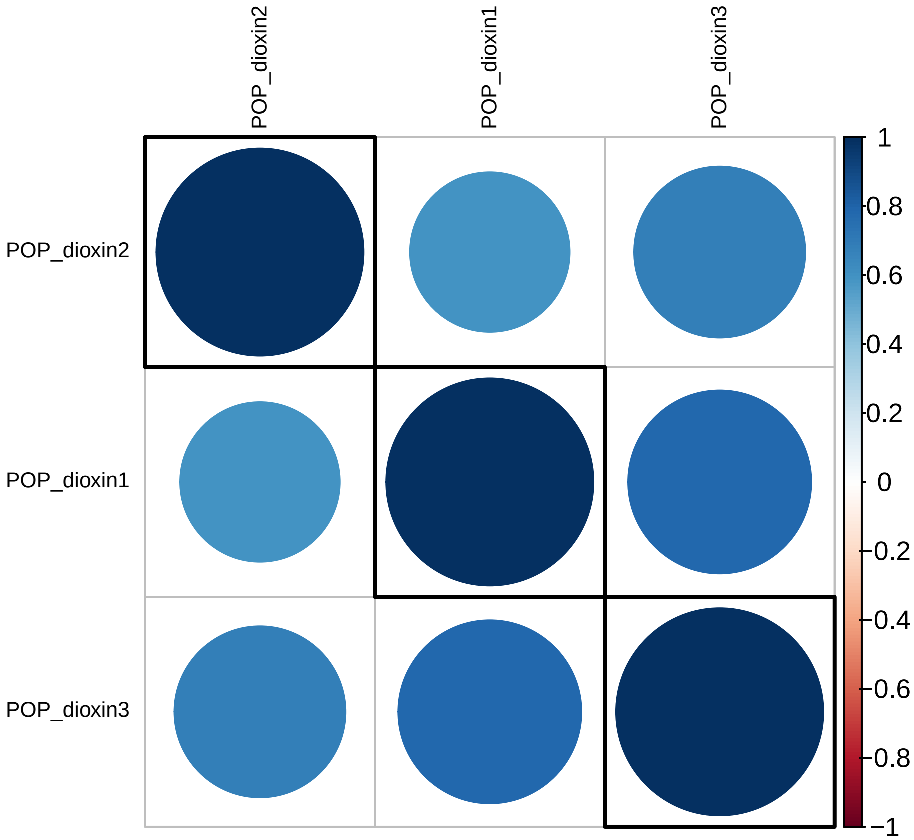

```
# Estella's work 1
library(corrplot)
```

```
## corrplot 0.84 loaded
```

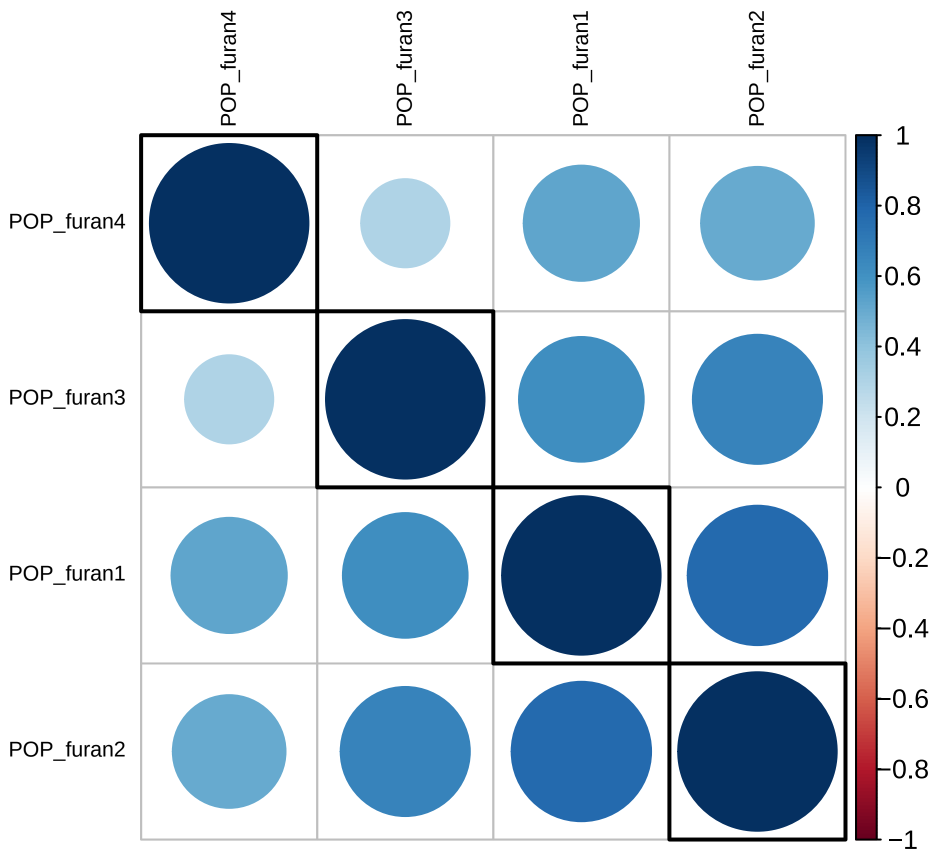
```r
library(ggplot2)

POP_PCB = c("POP_PCB1", "POP_PCB2","POP_PCB3", "POP_PCB4",
            "POP_PCB5", "POP_PCB6","POP_PCB7", "POP_PCB8",
            "POP_PCB9", "POP_PCB10", "POP_PCB11")

POP_PCB_data <- pollutants [, POP_PCB]
cc = cor(POP_PCB_data , method = "spearman")

# cluster my POP_PCB so that those with similar patterns
# of correlation coefficients are closer together.
# https://jkzorz.github.io/2019/06/11/Correlation-heatmaps.html
corrplot(cc, tl.col = "black", order = "hclust", hclust.method = "average",
         addrect = 4, tl.cex = 0.7)
```




```r
# Weiwei's work Part 1
POP_dioxin = c("POP_dioxin1", "POP_dioxin2","POP_dioxin3")
POP_dioxin_data <- pollutants [, POP_dioxin]

# cluster my POP_dioxin so that those with similar patterns
# of correlation coefficients are closer together.
cc.dioxin = cor(POP_dioxin_data , method = "spearman")
corrplot(cc.dioxin, tl.col = "black", order = "hclust",
         hclust.method = "average", addrect = 3, tl.cex = 0.7)
```




```
# Weiwei's work Part 2
POP_furan = c("POP_furan1", "POP_furan2","POP_furan3","POP_furan4")
POP_furan_data <- pollutants [, POP_furan]

# cluster my POP_dioxin so that those with similar patterns
# of correlation coefficients are closer together.
cc.furan = cor(POP_furan_data , method = "spearman")
corrplot(cc.furan, tl.col = "black", order = "hclust",
         hclust.method = "average", addrect = 4, tl.cex = 0.7)
```




```r
# Estella's work 3
f <- as.formula(
  paste("length", paste("(", paste(POP_PCB, collapse = "+"), ")^2"), sep="~"))

m_pcb <- lm(f, data = pollutants)
summary(m_pcb)
```

```
##
## Call:
## lm(formula = f, data = pollutants)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.53819 -0.16080 -0.01896  0.12149  1.20671
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)            1.153e+00  2.892e-02  39.876  < 2e-16 ***
## POP_PCB1              -6.741e-06  3.521e-06  -1.915  0.05591 .
## POP_PCB2               3.801e-06  9.328e-06   0.407  0.68378
## POP_PCB3               6.747e-06  6.701e-06   1.007  0.31431
## POP_PCB4               1.373e-06  3.278e-06   0.419  0.67539
## POP_PCB5               1.920e-06  3.267e-06   0.588  0.55680
## POP_PCB6              -3.673e-06  4.336e-06  -0.847  0.39729
## POP_PCB7              -5.281e-06  4.697e-06  -1.124  0.26126
## POP_PCB8              -1.073e-05  8.331e-06  -1.288  0.19796
## POP_PCB9              -1.833e-06  5.806e-06  -0.316  0.75232
```

```
## POP_PCB10            2.720e-03  2.088e-03   1.303  0.19311
## POP_PCB11            4.644e-04  9.916e-04   0.468  0.63969
## POP_PCB1:POP_PCB2    9.529e-11  2.113e-10   0.451  0.65216
## POP_PCB1:POP_PCB3   -6.580e-10  4.156e-10  -1.583  0.11377
## POP_PCB1:POP_PCB4    1.116e-10  1.917e-10   0.582  0.56080
## POP_PCB1:POP_PCB5   -1.621e-11  1.318e-10  -0.123  0.90218
## POP_PCB1:POP_PCB6    6.244e-11  2.176e-10   0.287  0.77423
## POP_PCB1:POP_PCB7    2.221e-11  2.742e-10   0.081  0.93548
## POP_PCB1:POP_PCB8   -5.209e-10  2.693e-10  -1.935  0.05340 .
## POP_PCB1:POP_PCB9    4.146e-10  2.287e-10   1.813  0.07020 .
## POP_PCB1:POP_PCB10   1.675e-07  1.311e-07   1.277  0.20183
## POP_PCB1:POP_PCB11  -6.663e-08  7.321e-08  -0.910  0.36303
## POP_PCB2:POP_PCB3    1.673e-09  8.717e-10   1.919  0.05537 .
## POP_PCB2:POP_PCB4   -6.761e-10  4.688e-10  -1.442  0.14963
## POP_PCB2:POP_PCB5    3.840e-10  3.632e-10   1.057  0.29069
## POP_PCB2:POP_PCB6   -1.426e-09  5.834e-10  -2.444  0.01474 *
## POP_PCB2:POP_PCB7    1.532e-09  6.770e-10   2.264  0.02387 *
## POP_PCB2:POP_PCB8    2.135e-09  8.207e-10   2.602  0.00945 **
## POP_PCB2:POP_PCB9   -1.356e-09  7.249e-10  -1.870  0.06183 .
## POP_PCB2:POP_PCB10  -1.232e-06  4.242e-07  -2.904  0.00378 **
## POP_PCB2:POP_PCB11   3.388e-07  2.013e-07   1.683  0.09270 .
## POP_PCB3:POP_PCB4   -3.996e-11  1.199e-10  -0.333  0.73900
## POP_PCB3:POP_PCB5    4.665e-11  2.413e-10   0.193  0.84674
## POP_PCB3:POP_PCB6   -3.741e-10  2.662e-10  -1.405  0.16029
## POP_PCB3:POP_PCB7    6.438e-10  2.896e-10   2.223  0.02649 *
## POP_PCB3:POP_PCB8    7.340e-10  8.821e-10   0.832  0.40563
## POP_PCB3:POP_PCB9   -4.221e-10  5.470e-10  -0.772  0.44059
## POP_PCB3:POP_PCB10  -4.835e-07  2.555e-07  -1.892  0.05885 .
## POP_PCB3:POP_PCB11   7.155e-08  7.874e-08   0.909  0.36382
## POP_PCB4:POP_PCB5    3.002e-12  6.669e-11   0.045  0.96410
## POP_PCB4:POP_PCB6    1.788e-10  1.543e-10   1.159  0.24694
## POP_PCB4:POP_PCB7   -2.117e-10  1.579e-10  -1.341  0.18019
## POP_PCB4:POP_PCB8   -4.525e-11  3.961e-10  -0.114  0.90908
## POP_PCB4:POP_PCB9    1.217e-10  2.625e-10   0.464  0.64294
## POP_PCB4:POP_PCB10   1.345e-07  8.933e-08   1.505  0.13265
## POP_PCB4:POP_PCB11   1.685e-08  5.047e-08   0.334  0.73861
## POP_PCB5:POP_PCB6    4.714e-11  1.390e-10   0.339  0.73458
## POP_PCB5:POP_PCB7   -1.555e-10  1.446e-10  -1.076  0.28244
## POP_PCB5:POP_PCB8   -4.639e-10  3.185e-10  -1.457  0.14562
## POP_PCB5:POP_PCB9   -1.626e-11  1.822e-10  -0.089  0.92890
## POP_PCB5:POP_PCB10   9.703e-08  9.241e-08   1.050  0.29406
## POP_PCB5:POP_PCB11  -5.549e-08  4.079e-08  -1.360  0.17407
## POP_PCB6:POP_PCB7   -2.248e-11  1.147e-10  -0.196  0.84474
## POP_PCB6:POP_PCB8    7.086e-10  3.808e-10   1.861  0.06310 .
## POP_PCB6:POP_PCB9    4.295e-10  3.267e-10   1.315  0.18895
## POP_PCB6:POP_PCB10   2.152e-07  1.182e-07   1.820  0.06909 .
## POP_PCB6:POP_PCB11  -4.299e-08  2.038e-08  -2.109  0.03523 *
## POP_PCB7:POP_PCB8   -1.029e-09  4.279e-10  -2.404  0.01645 *
## POP_PCB7:POP_PCB9   -2.467e-10  3.622e-10  -0.681  0.49603
## POP_PCB7:POP_PCB10  -3.893e-08  1.308e-07  -0.298  0.76608
## POP_PCB7:POP_PCB11   4.226e-08  3.690e-08   1.145  0.25246
## POP_PCB8:POP_PCB9    1.317e-10  5.297e-10   0.249  0.80373
## POP_PCB8:POP_PCB10   5.264e-07  3.029e-07   1.738  0.08265 .
## POP_PCB8:POP_PCB11  -5.764e-08  1.285e-07  -0.449  0.65382
```

```
## POP_PCB9:POP_PCB10  -2.240e-08  1.448e-07  -0.155  0.87712
## POP_PCB9:POP_PCB11   7.916e-08  6.811e-08   1.162  0.24548
## POP_PCB10:POP_PCB11 -5.384e-05  2.694e-05  -1.999  0.04599 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2377 on 797 degrees of freedom
## Multiple R-squared:  0.1666, Adjusted R-squared:  0.09763
## F-statistic: 2.415 on 66 and 797 DF,  p-value: 1.316e-08
```

```
f_dioxin <- as.formula(
  (paste("length", paste("(", paste(POP_dioxin, collapse = " + "), ")^2"), sep = " ~")))
m_dioxin <- lm(f_dioxin, data = pollutants)
summary(m_dioxin)
```

```
##
## Call:
## lm(formula = f_dioxin, data = pollutants)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.55482 -0.17673 -0.03284  0.14352  1.25543
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)               1.146e+00  1.839e-02  62.307  < 2e-16 ***
## POP_dioxin1              -4.963e-05  4.780e-04  -0.104    0.917
## POP_dioxin2              -1.938e-03  3.924e-04  -4.938 9.48e-07 ***
## POP_dioxin3              -2.509e-05  5.898e-05  -0.425    0.671
## POP_dioxin1:POP_dioxin2   1.207e-06  4.234e-06   0.285    0.776
## POP_dioxin1:POP_dioxin3  -4.810e-08  6.600e-08  -0.729    0.466
## POP_dioxin2:POP_dioxin3   3.850e-07  4.994e-07   0.771    0.441
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2435 on 857 degrees of freedom
## Multiple R-squared:  0.0598, Adjusted R-squared:  0.05322
## F-statistic: 9.084 on 6 and 857 DF,  p-value: 1.192e-09
```

```
# interaction in furan
f_furan <- as.formula(
  (paste("length", paste("(", paste(POP_furan, collapse = " + "), ")^2"), sep = " ~")))

m_furan <- lm(f_furan, data = pollutants)
summary(m_furan)
```

```
##
## Call:
## lm(formula = f_furan, data = pollutants)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.61888 -0.18547 -0.02491  0.14317  1.26106
##
## Coefficients:
```

```
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)             1.127e+00  2.511e-02  44.879   <2e-16 ***
## POP_furan1             -8.479e-03  8.177e-03  -1.037   0.3001
## POP_furan2             -4.371e-03  1.058e-02  -0.413   0.6795
## POP_furan3             -9.871e-03  4.039e-03  -2.444   0.0147 *
## POP_furan4              3.225e-03  2.008e-03   1.606   0.1086
## POP_furan1:POP_furan2   4.511e-05  3.122e-04   0.145   0.8851
## POP_furan1:POP_furan3  -3.070e-04  5.014e-04  -0.612   0.5406
## POP_furan1:POP_furan4   3.129e-04  4.206e-04   0.744   0.4571
## POP_furan2:POP_furan3   9.340e-04  6.074e-04   1.538   0.1245
## POP_furan2:POP_furan4  -5.346e-04  5.612e-04  -0.953   0.3410
## POP_furan3:POP_furan4   1.536e-04  2.389e-04   0.643   0.5203
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2468 on 853 degrees of freedom
## Multiple R-squared:  0.03869,    Adjusted R-squared:  0.02742
## F-statistic: 3.433 on 10 and 853 DF,  p-value: 0.0001986
```

```r
# Estella's work 4
# setting threshold of pvalue to be 0.05 and assess possible interaction terms
pvalues <- summary(m_pcb)$coefficients[,4]
p_threshold = 0.05
selected <- which(pvalues <= p_threshold)
names(selected)
```

```
## [1] "(Intercept)"         "POP_PCB2:POP_PCB6"   "POP_PCB2:POP_PCB7"
## [4] "POP_PCB2:POP_PCB8"   "POP_PCB2:POP_PCB10"  "POP_PCB3:POP_PCB7"
## [7] "POP_PCB6:POP_PCB11"  "POP_PCB7:POP_PCB8"   "POP_PCB10:POP_PCB11"
```

4. Methods:

Describe your statistical analysis: What is your model? Did you use any transformations or extensions of the basic multiple linear regression model? How did you select a model? Does the model fit the data well? Are the necessary assumptions met? Be sure to explain and justify your decisions.

```r
train_data <- pollutants[1:600,]
test_data <- pollutants[601:nrow(pollutants),]
```

```r
#stepwise parameters selection without any interaction terms
M0 <- lm(length ~ 1, data = train_data) # minimal model
Mfull <- lm(length ~ ., data= train_data)

## 2 corresponds to AIC
## log(n) corresponds to BIC

# stepwise AIC
Mstart <- lm(length ~ ., data= train_data)
system.time({
  MAIC <- step(object = Mstart,
               scope = list(lower = M0, upper = Mfull),
               direction = "both", trace = 0, k = 2)
})
```

```
##    user  system elapsed
```

```
##    1.634   0.149   1.803
```

```r
#stepwiseBIC
system.time({
  MBIC <- step(object = Mstart,
               scope = list(lower = M0, upper = Mfull),
               direction = "both", trace = 0, k = log(nrow(train_data)))
})
```

```
##    user  system elapsed
##   1.729   0.150   1.976
```

```r
#stepwiseB_Adjusted R2
MAIC
```

```
##
## Call:
## lm(formula = length ~ POP_PCB1 + POP_PCB10 + POP_furan1 + POP_furan2 +
##     whitecell_count + monocyte_pct + edu_cat + race_cat + male +
##     ageyrs + ln_lbxcot, data = train_data)
##
## Coefficients:
##     (Intercept)         POP_PCB1        POP_PCB10       POP_furan1
##       1.443e+00       -5.602e-07        1.780e-03       -6.532e-03
##      POP_furan2  whitecell_count     monocyte_pct         edu_cat2
##       8.968e-03       -1.029e-02       -6.643e-03        4.105e-02
##        edu_cat3         edu_cat4  race_catMexican    race_catBlack
##       6.188e-02        8.254e-02       -3.635e-03        3.584e-02
##   race_catWhite         malemale           ageyrs        ln_lbxcot
##      -4.701e-02       -4.513e-02       -5.820e-03        7.573e-03
```

```r
MBIC
```

```
##
## Call:
## lm(formula = length ~ POP_furan3 + ageyrs, data = train_data)
##
## Coefficients:
## (Intercept)   POP_furan3       ageyrs
##    1.355743     0.005969    -0.006922
```

```r
# stepwise parameters selection with any interaction terms
M0 <- lm(length ~ 1, data = train_data) # minimal model

# tail to remove length column
single <- paste(tail(colnames(train_data),-1), collapse = " + ")
# tail to remove intercept column
interaction <- paste(tail(names(selected),-1), collapse = " + ")
f_interaction <- as.formula(
  paste("length", paste("(", single,"+", interaction, ")"), sep = " ~"))

Mfull <- lm(f_interaction, data = train_data)
Mstart <- lm(f_interaction, data = train_data)

# stepwise AIC
Mstart <- lm(length ~ ., data= train_data)
system.time({
```

```r
  MAIC_Interaction <- step(object = Mstart,
                           scope = list(lower = M0, upper = Mfull),
                           direction = "both", trace = 0, k = 2)
})
```

```
##    user  system elapsed
##   1.738   0.156   1.903
```

```r
#stepwiseBIC
system.time({
  MBIC_Interaction <- step(object = Mstart,
                           scope = list(lower = M0, upper = Mfull),
                           direction = "both", trace = 0,
                           k = log(nrow(train_data)))
})
```

```
##    user  system elapsed
##   2.030   0.202   2.244
```

```r
#stepwiseB_Adjusted R2
MAIC_Interaction
```

```
##
## Call:
## lm(formula = length ~ POP_PCB1 + POP_PCB6 + POP_PCB10 + POP_PCB11 +
##     POP_dioxin2 + POP_furan3 + whitecell_count + monocyte_pct +
##     BMI + edu_cat + race_cat + male + ageyrs + ln_lbxcot + POP_PCB10:POP_PCB11,
##     data = train_data)
##
## Coefficients:
##         (Intercept)             POP_PCB1             POP_PCB6
##           1.473e+00           -8.511e-07            1.150e-06
##           POP_PCB10            POP_PCB11          POP_dioxin2
##           2.839e-03            9.157e-04           -6.180e-04
##          POP_furan3      whitecell_count         monocyte_pct
##           4.745e-03           -9.472e-03           -6.707e-03
##                 BMI             edu_cat2             edu_cat3
##          -2.272e-03            4.205e-02            5.902e-02
##            edu_cat4      race_catMexican        race_catBlack
##           7.656e-02            1.408e-03            4.927e-02
##       race_catWhite             malemale               ageyrs
##          -3.842e-02           -3.208e-02           -6.126e-03
##           ln_lbxcot  POP_PCB10:POP_PCB11
##           7.374e-03           -2.457e-05
```

```r
MBIC_Interaction
```

```
##
## Call:
## lm(formula = length ~ POP_furan3 + ageyrs, data = train_data)
##
## Coefficients:
## (Intercept)   POP_furan3       ageyrs
##    1.355743     0.005969    -0.006922
```

```r
# mxn's work
predAIC <- predict(MAIC, newdata=test_data)
```

```r
predBIC <- predict(MBIC, newdata=test_data)
predAICInteraction <- predict(MAIC_Interaction, newdata=test_data)
predBICInteraction <- predict(MBIC_Interaction, newdata=test_data)

mean((test_data$length - predAIC)^2)
```

```
## [1] 0.05336494
```

```r
mean((test_data$length - predBIC)^2)
```

```
## [1] 0.04804827
```

```r
mean((test_data$length - predAICInteraction)^2)
```

```
## [1] 0.05230268
```

```r
mean((test_data$length - predBICInteraction)^2)
```

```
## [1] 0.04804827
```