excercises_week_5

Lindsey Greenhill

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excercises 4.4 and 4.8

Question 3

Part a

The scatterplot we created of Mortality rate vs. Nitric Oxide suggests that a linear regression without any transformations will not fit the data very well, as many of the data points are clustered around the start of the range and only a few data points appear around the end of the range.
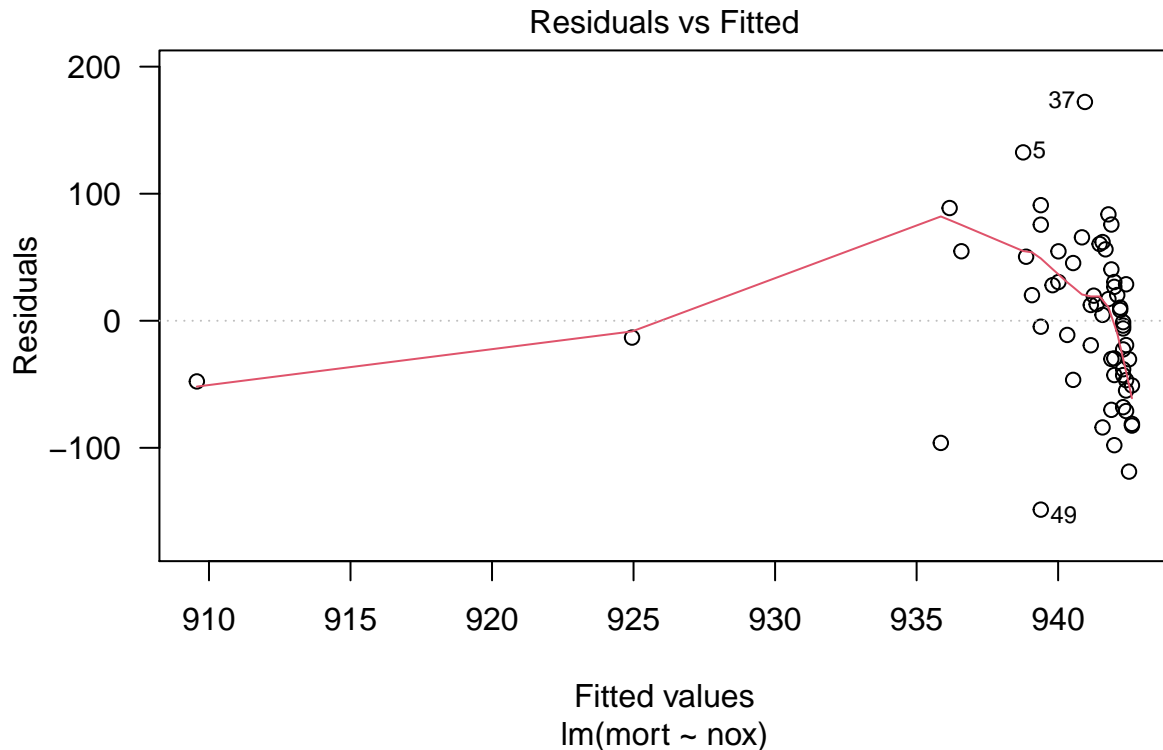
Fitting a linear regression (fit_1) and looking at its residuals confirms that a linear regression may not be the best fit for this data. The residuals are not randomly distributed and are clustered at the end of the range, telling us that the linear regression is not a good fit.

```r
# creating scatterplot. Data looks like a lot of the data is very clustered
# around 0 with some values much further away.

pollution %>%
  ggplot(aes(x = nox, y = mort)) +
  geom_point() +
  labs(title = "Mortality Rate vs. Nitric Oxide",
       x =  "Nitric Oxide Level",
       y =  "Mortality Rate") +
  theme_classic()
```

Mortality Rate vs. Nitric Oxide
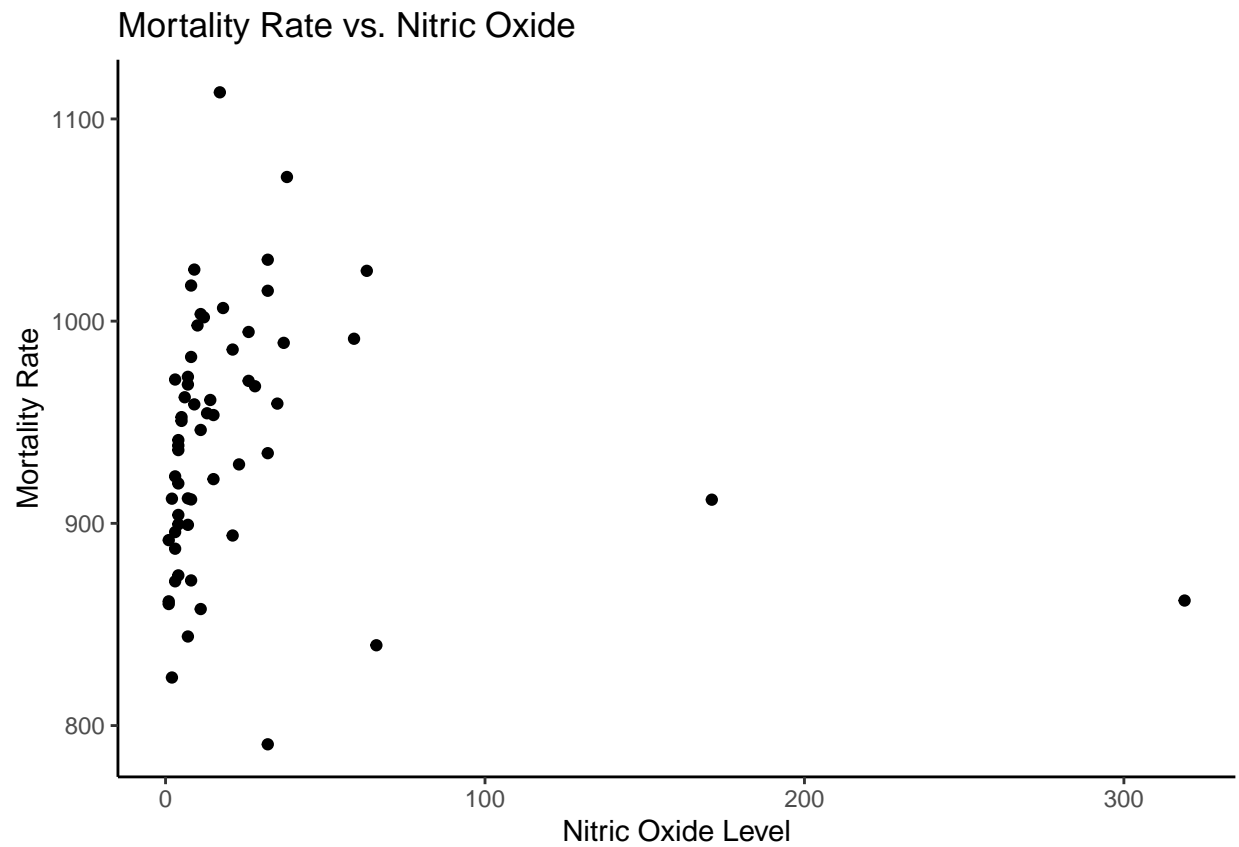

```r
# fitting the linear regression

fit_1 <- lm(mort ~ nox, data = pollution)

# creating the residuals

plot(fit_1, which = 1, las = 1, )
```

Residuals vs Fitted

Residuals vs Fitted plot for lm(mort ~ nox), with Fitted values on the x-axis and Residuals on the y-axis. Points labeled 37, 5, and 49 are highlighted.

Part b

I chose to do a logarithmic transformation of the data, meaning that I ran a regression on mortality rate vs. log(nox), where nox is our nitric oxide variable from part a. The residuals for this regression look much better than the linear regression from part a. They are relatively randomly distributed and aren't clustered around any one point, telling us that the model is not a bad fit.
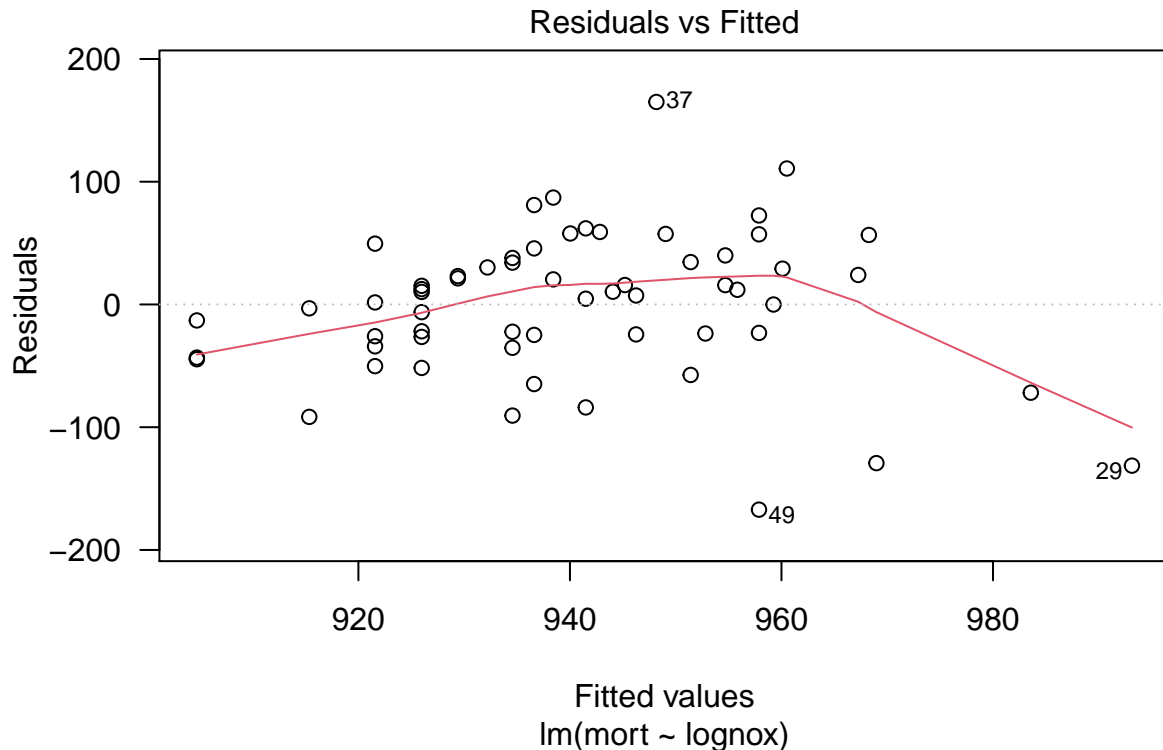
```
# creating a log version of nox

pollution <- pollution %>%
  mutate(lognox = log(nox))


fit_2 <- lm(mort ~ lognox, data = pollution)

# creating the residuals. This residual plots look a lot better than the other
# residuals. They are more randomly distributed and not clustered.

plot(fit_2, which = 1, las = 1, )
```

Residuals vs Fitted

Fitted values
lm(mort ~ lognox)

Part c

The slope coefficient from the model in b is 15,34. The interpretation of this coefficient is a difference of 1% in nitrix oxide levels is associated with an (approximate) positive difference of .1534% in mortality rate.

Part d

To determine whether or not I should use logarithmic transformations for sulfur dioxide and hydrocarbons, I ran a linear regression on mortality rate vs. each variable and mortality rate vs. each log variable and compared the scatter plots and residual plots.

The residual plot for the variable follows the scatterplot.

For both hc and so2, the log version of the regression produces residuals that appear more randomly distributed, especially for hc. So, I decided to use the log version of both so2 and hc in my regression.

```
# creating logged versions of the variables

pollution <- pollution %>%
  mutate(logso2 = log(so2),
         loghc = log(hc),
         logmort = log(mort))

# maybe want to do the log of so2
```
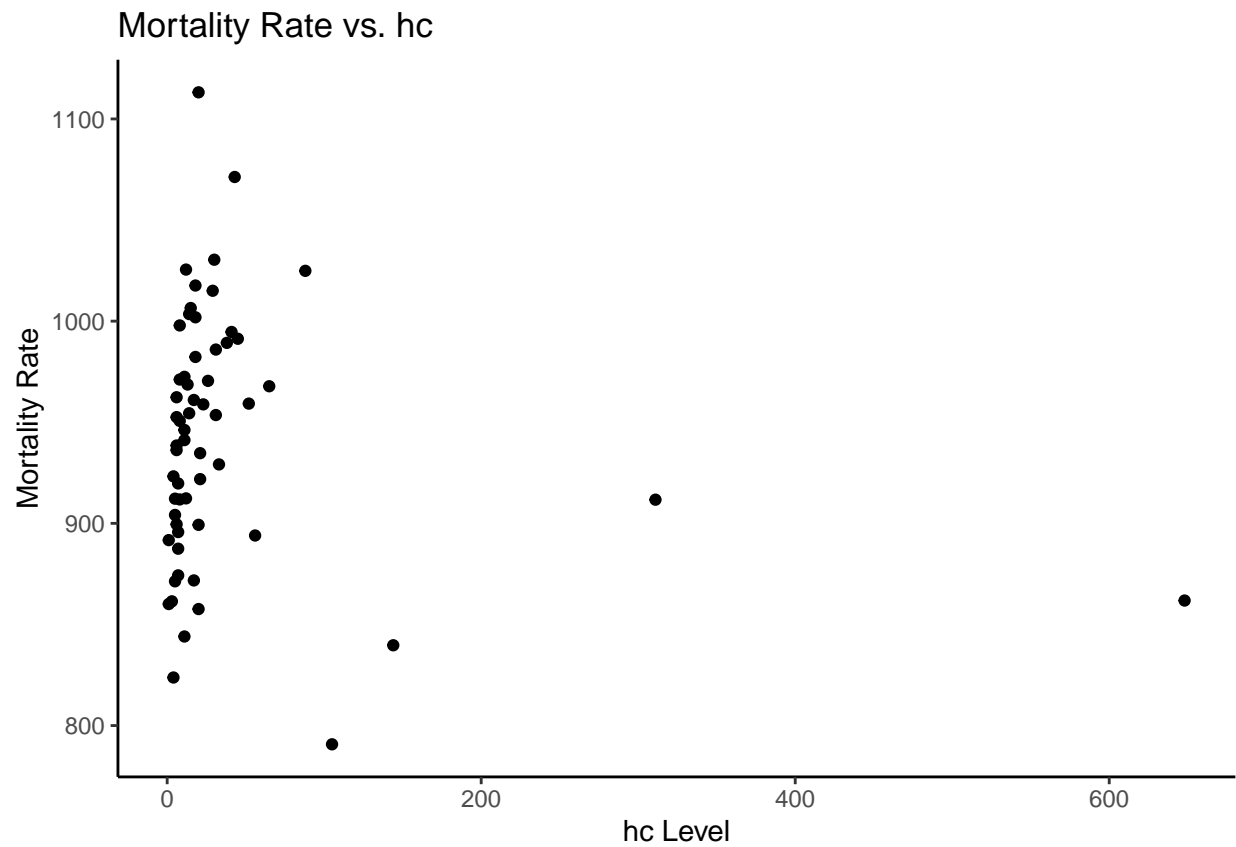
```
pollution %>%
  ggplot(aes(x = so2, y = mort)) +
  geom_point() +
  labs(title = "Mortality Rate vs. so2",
       x =  "so2 Level",
       y =  "Mortality Rate") +
  theme_classic()
```


Mortality Rate vs. so2
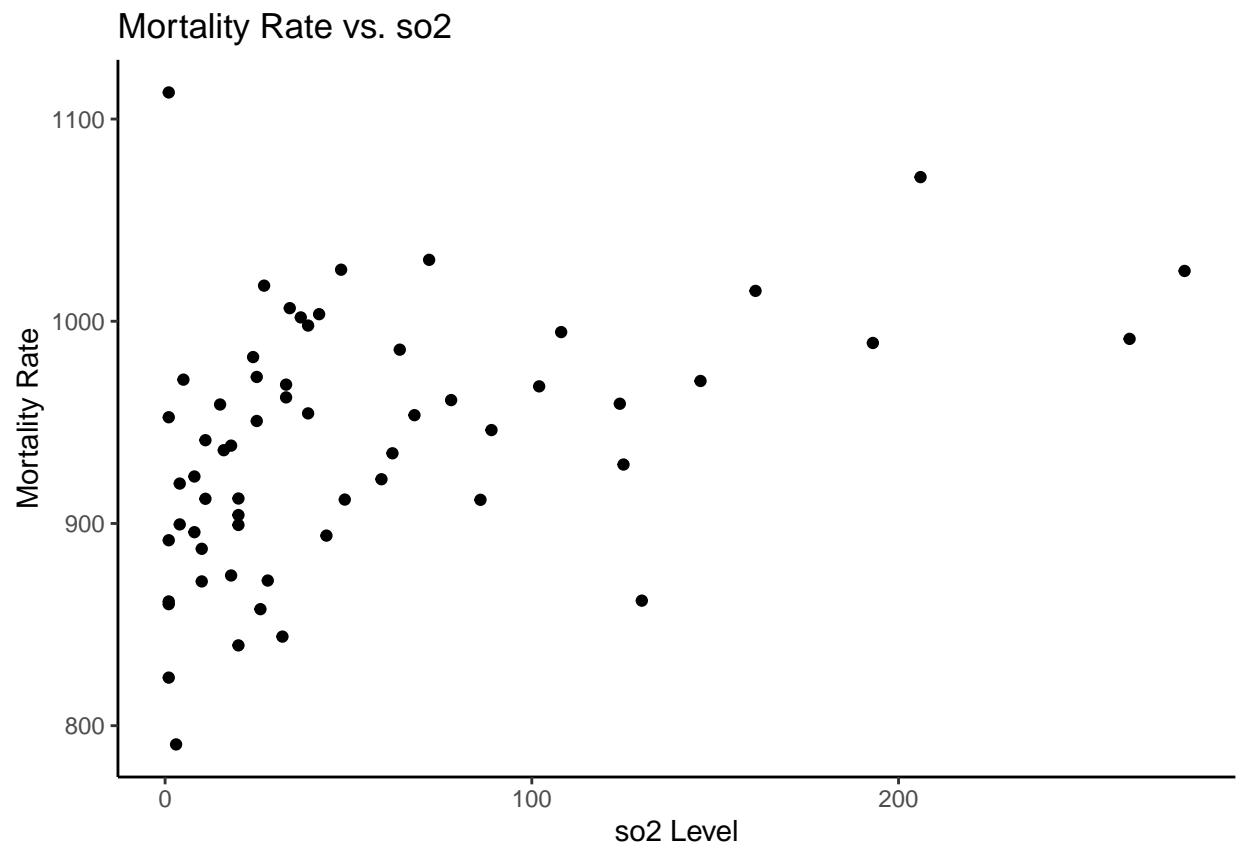
```
# definitely want to do the log of hc

pollution %>%
  ggplot(aes(x = hc, y = mort)) +
  geom_point() +
  labs(title = "Mortality Rate vs. hc",
       x =  "hc Level",
       y =  "Mortality Rate") +
  theme_classic()
```

Mortality Rate vs. hc
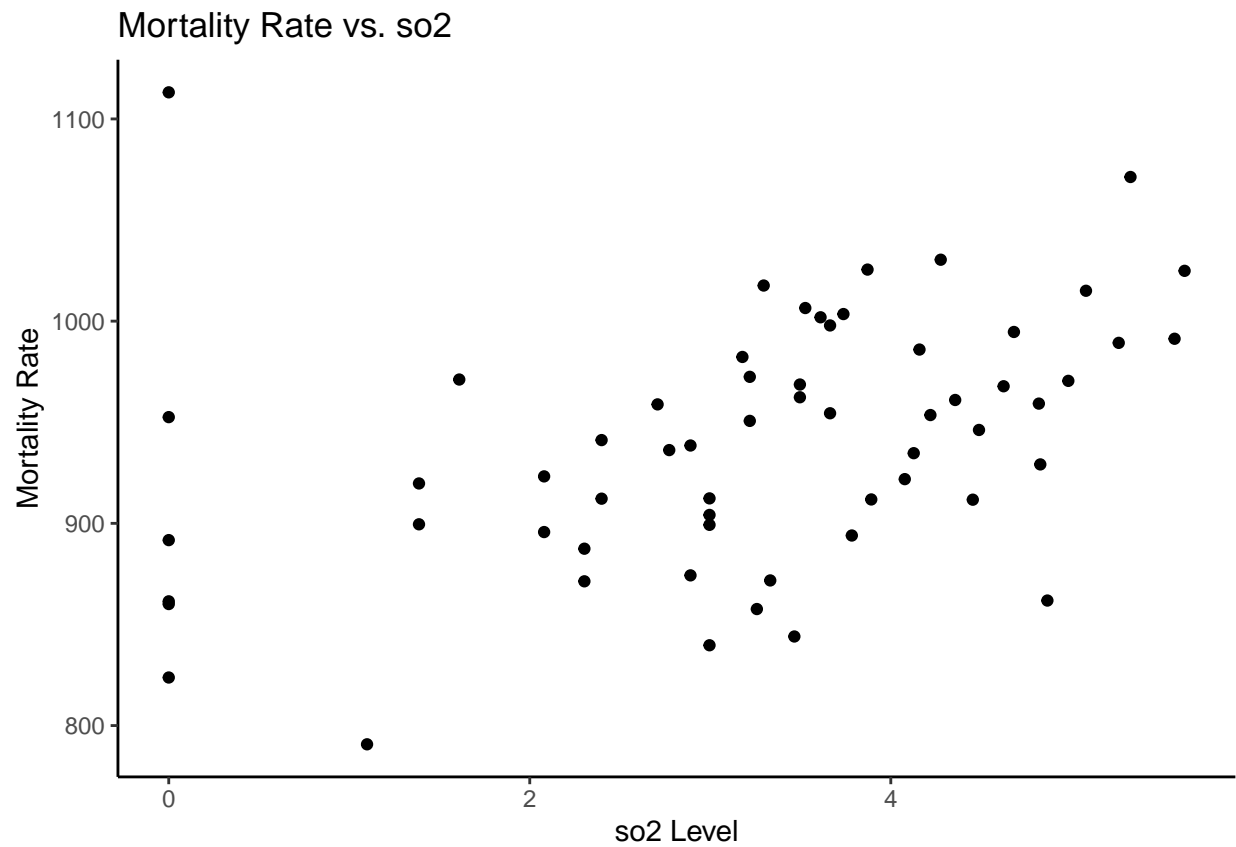


```
pollution %>%
  ggplot(aes(x = logso2, y = mort)) +
  geom_point() +
  labs(title = "Mortality Rate vs. so2",
       x =  "so2 Level",
       y =  "Mortality Rate") +
  theme_classic()
```

Mortality Rate vs. so2


```r
# definitely want to do the log of hc

pollution %>%
  ggplot(aes(x = loghc, y = mort)) +
  geom_point() +
  labs(title = "Mortality Rate vs. hc",
       x =  "hc Level",
       y =  "Mortality Rate") +
  theme_classic()
```
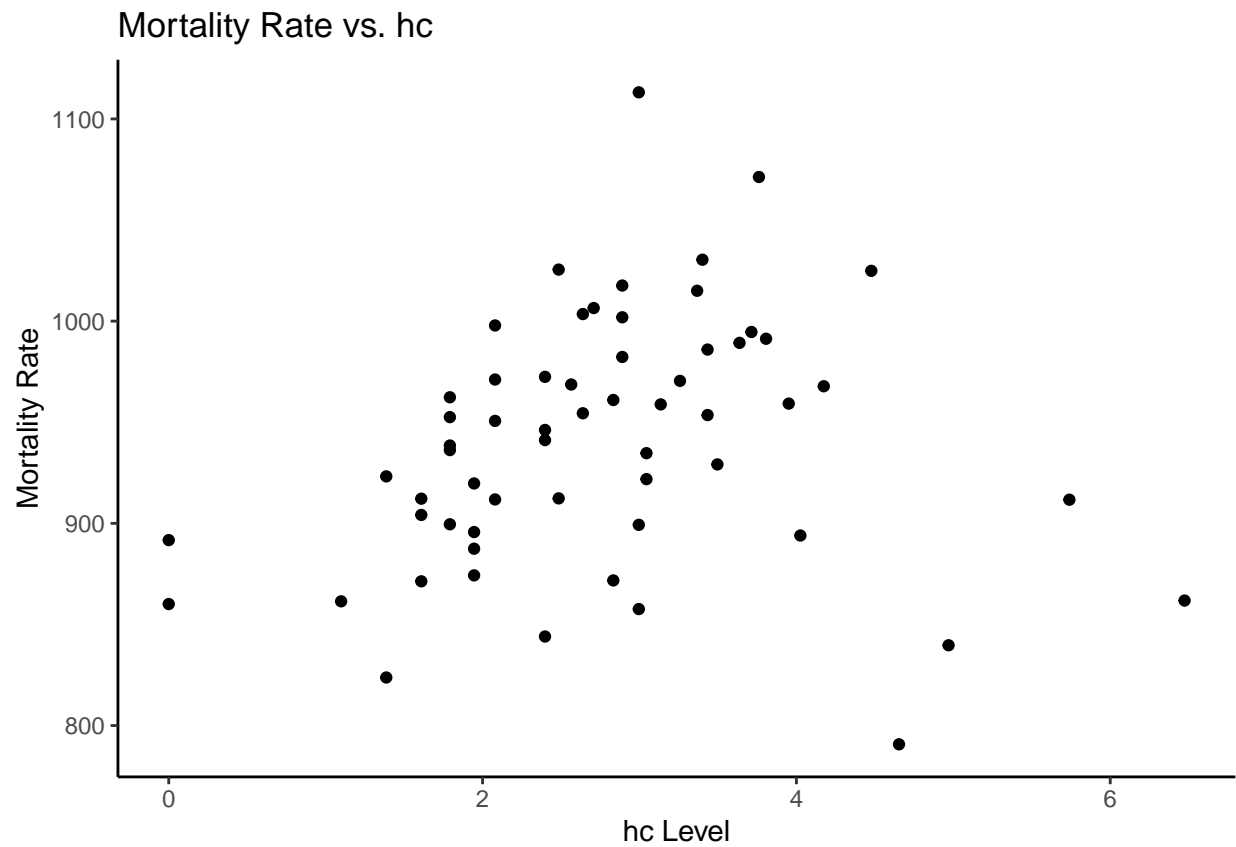
Mortality Rate vs. hc


```
# creating models and residul plots for so2 and hc for log and non log

fit_so2 <- lm(mort ~ so2, data = pollution)
fit_logso2 <- lm(mort ~ logso2, data = pollution)

plot(fit_so2, which = 1, las = 1, )
```

Residuals vs Fitted

Residuals

lm(mort ~ so2)

Fitted values

```r
plot(fit_logso2, which = 1, las = 1, )
```

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Residuals vs Fitted

Fitted values
lm(mort ~ logso2)
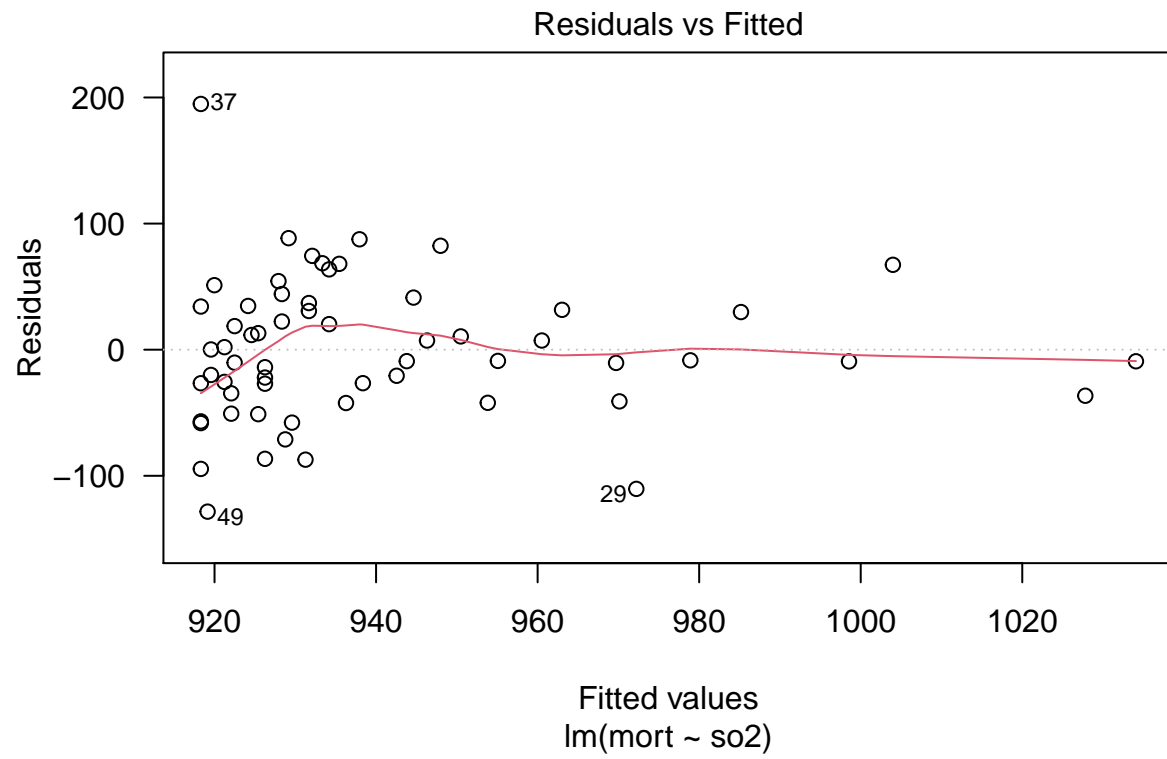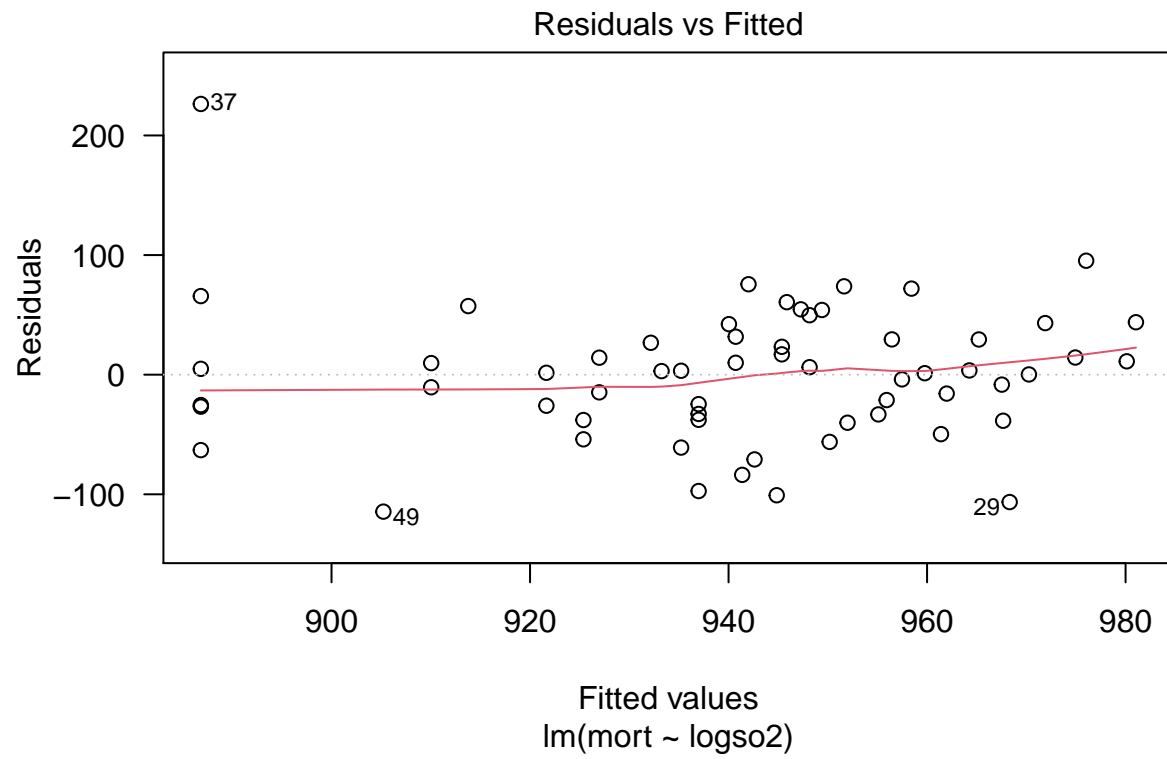
```
fit_hc <- lm(mort ~ hc, data = pollution)
fit_loghc <- lm(mort ~ loghc, data = pollution)

plot(fit_so2, which = 1, las = 1, )
```

Residuals vs Fitted

Fitted values
lm(mort ~ so2)

```
plot(fit_logso2, which = 1, las = 1, )
```

Residuals vs Fitted

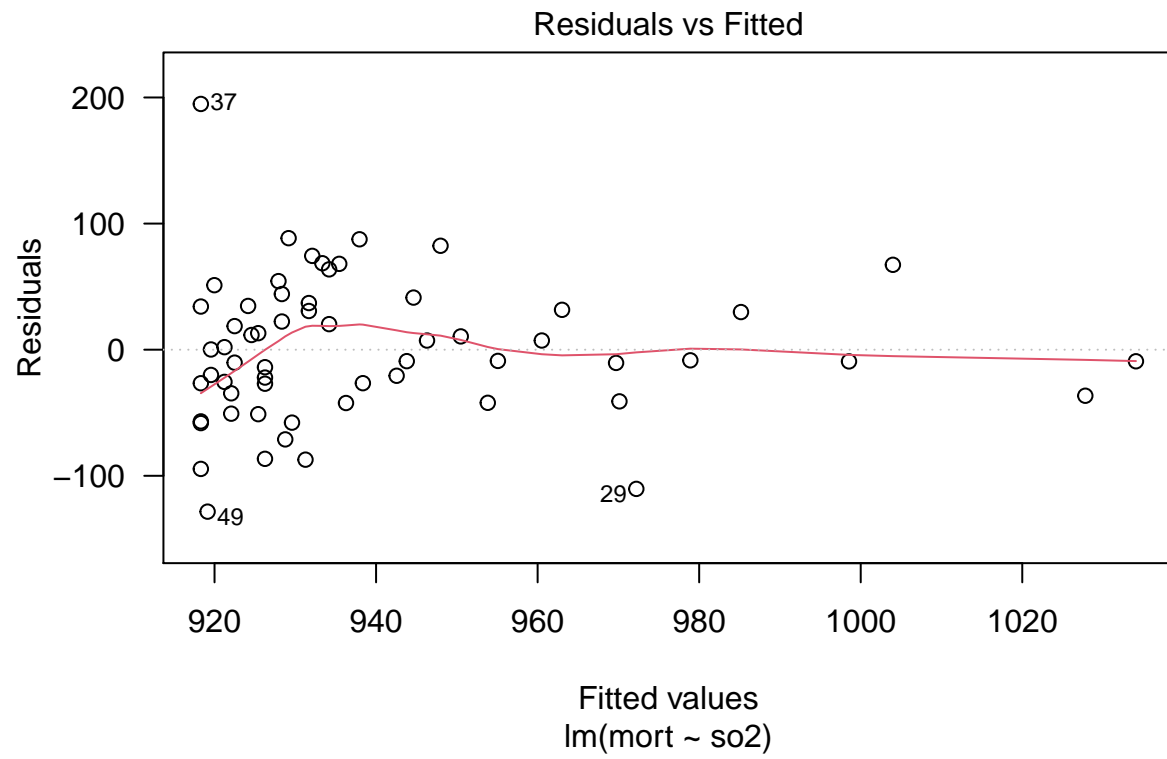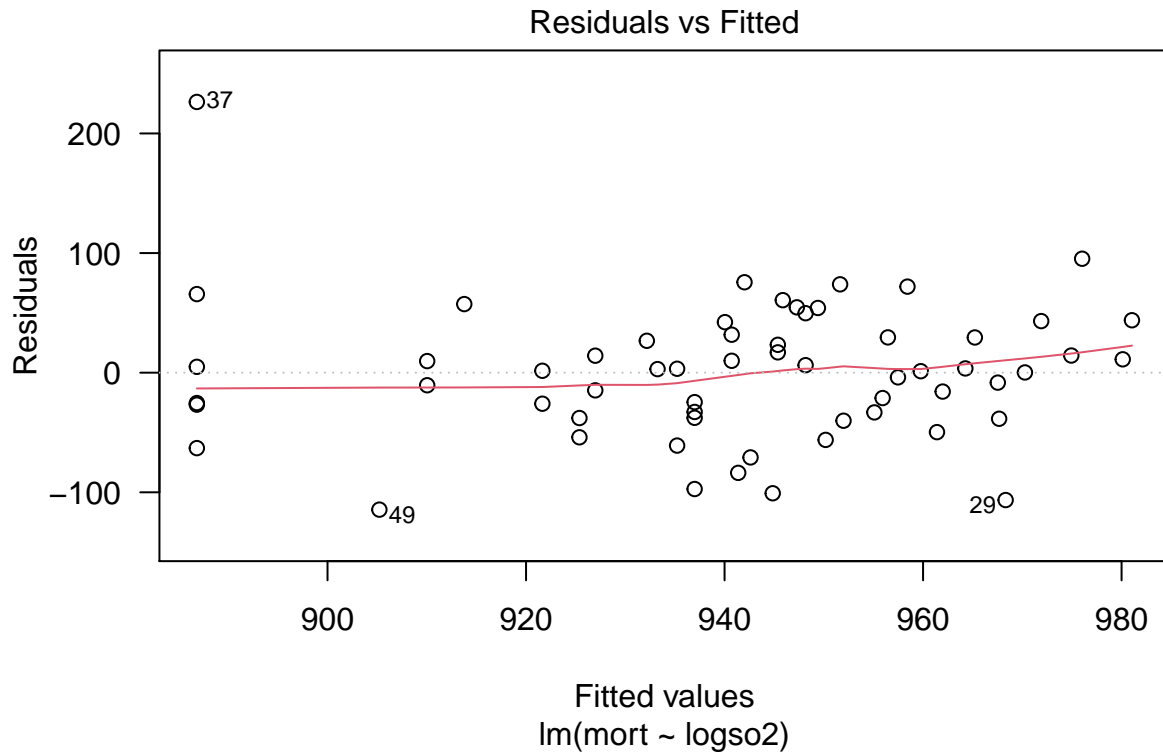The plots below compare the residuals for the non log and log regressions (at this point, y is still not in log form). The residuals for the log regression are more evenly distributed and random, confirming my decision above to use the log version of both so2 and hc.

```r
# creating two regression to compare

fit_all <- lm(mort ~ nox + so2 + hc, data = pollution)

fit_all_log <- lm(mort ~ lognox + logso2 + loghc, data = pollution)

# the residuals look better for the logged model

plot(fit_all, which = 1, las = 1, )
```

Residuals vs Fitted
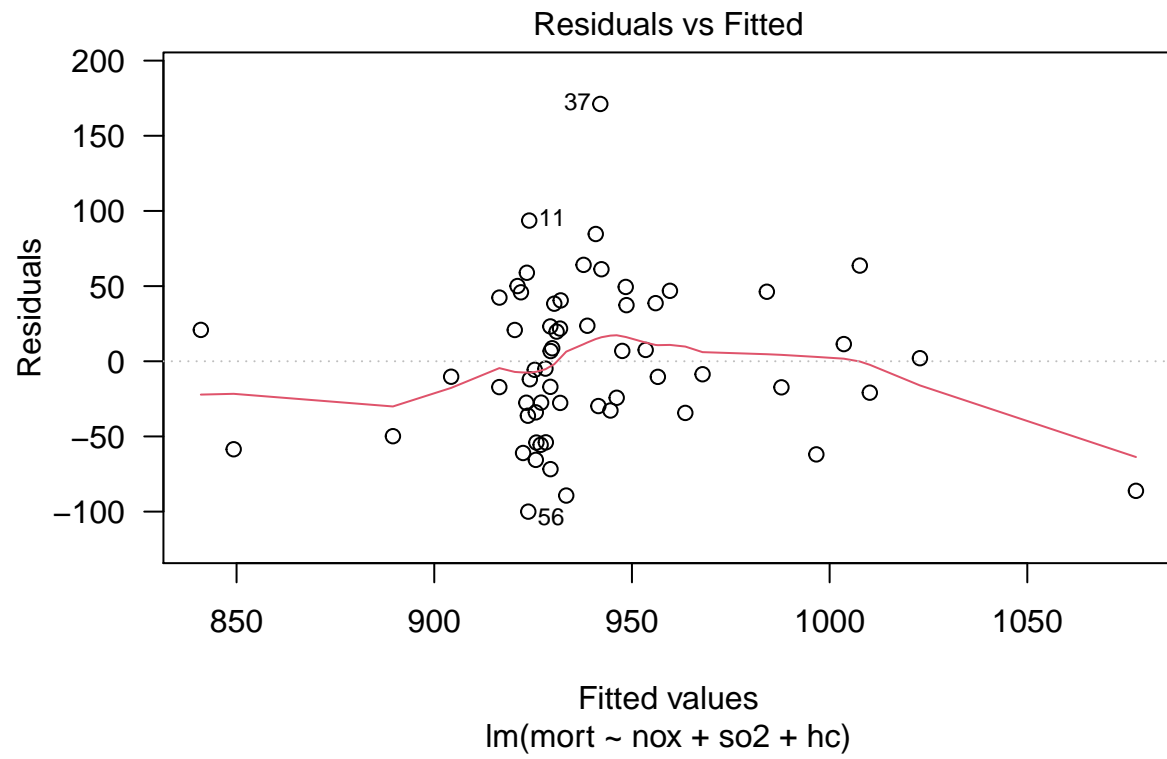
```
plot(fit_all_log, which = 1, las = 1, )
```

Residuals vs Fitted

Fitted values
lm(mort ~ lognox + logso2 + loghc)
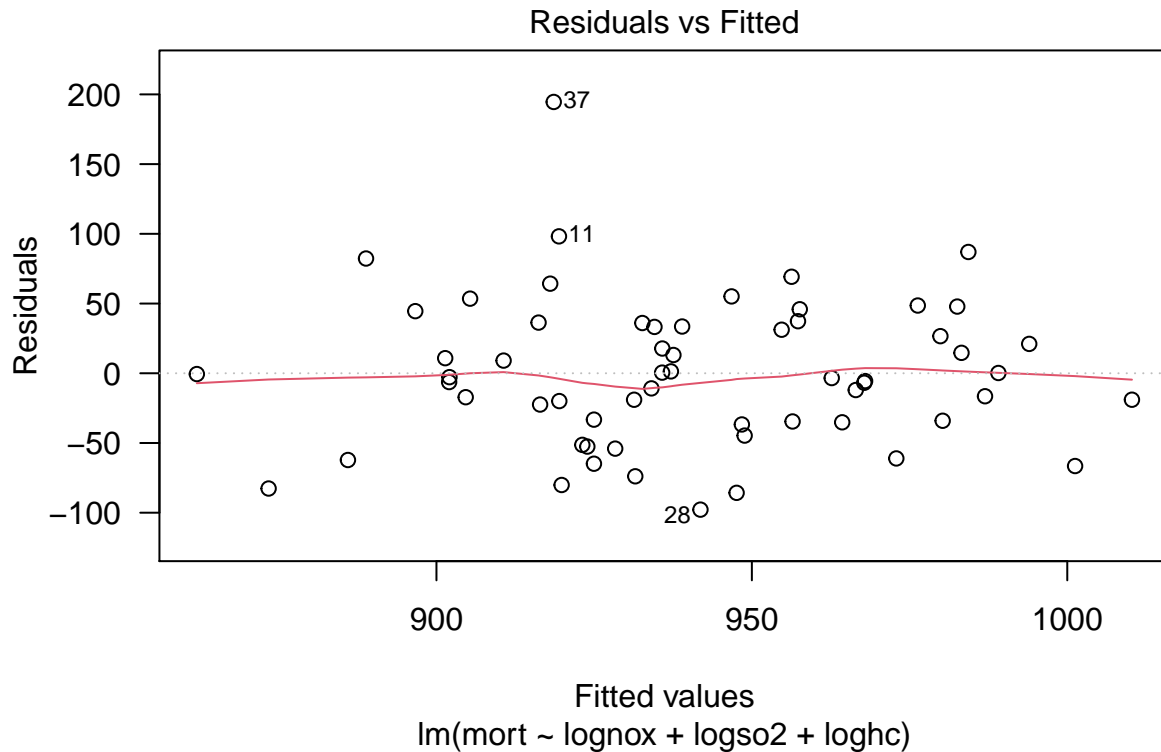
```
# log level.
# level log: 1% change in x is associated with a beta/100 change in y, on average
# log log: 1% change in x is associated with a beta % change in y
```

I also decided to see how running a regression on log mortality rate vs the log other variables affected the model. I would prefer to have both sides of the regression be logged, so the interpretation of the coefficients is simpler. Looking at the residual plot below, using log y in the regression doesn't appear to make the residuals any less random, so I will use log mortality in my model.

```
# benefit of also logging y: the coefficients become easier to interpret

fit_all_log_y <- lm(logmort ~ lognox + logso2 + loghc, data = pollution)

# logging the y doesn't seem to make the residuals less random

plot(fit_all_log_y, which = 1, las = 1, )
```

Residuals vs Fitted

Fitted values
lm(logmort ~ lognox + logso2 + loghc)
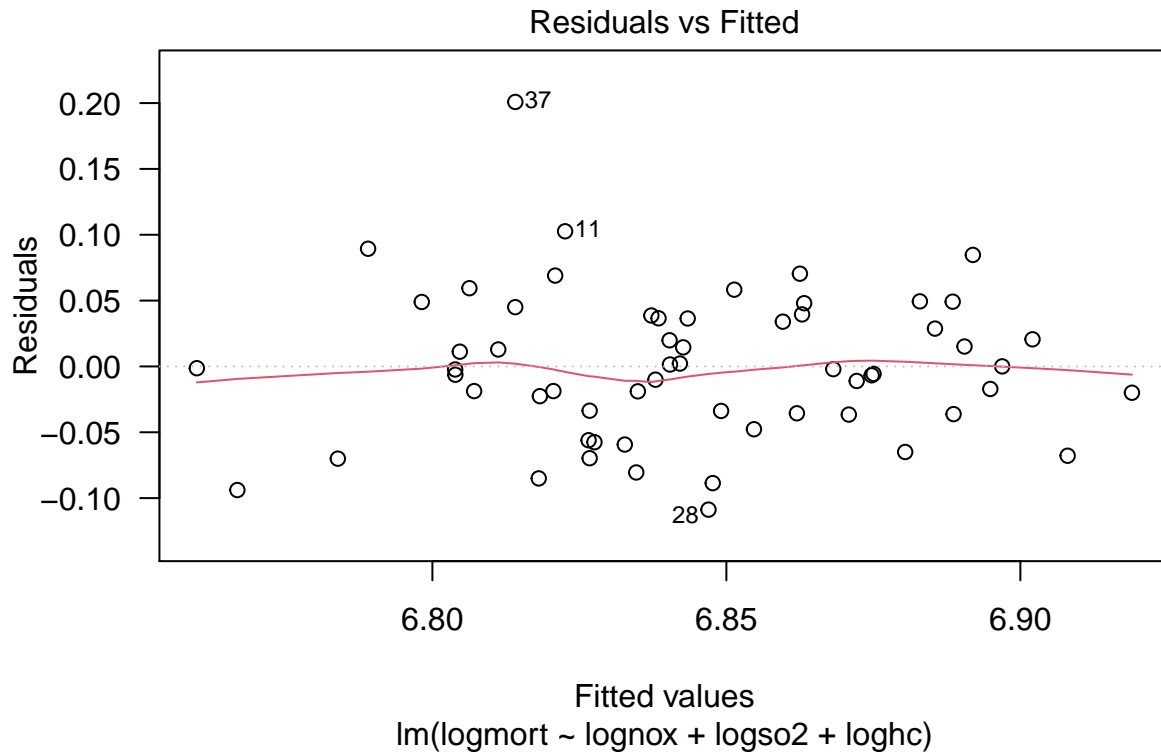
The plot below the fitted regression model. Because I couldn't include all 3 IV's, I displayed logmort vs lognox with loghc and logso2 held constant at their 25th, 50th, and 75th quantiles.

The table below shows the regression results for the model.

```r
# showing plot of fitted model

pollution %>%
  ggplot(aes(y = logmort)) +
  stat_function(fun = function(.x) 6.82675
                + .05984*.x +
                  (.01431*mean(pollution$logso2)) +
                  (-.06081*mean(pollution$loghc)),
                col  = "steelblue2") +
    stat_function(fun = function(.x) 6.82675
                + .05984*.x +
                  (.01431*quantile(pollution$logso2, probs = .25)) +
                  (-.06081*quantile(pollution$loghc, probs = .25)),
                col  = "indianred") +
      stat_function(fun = function(.x) 6.82675
                + .05984*.x +
                  (.01431*quantile(pollution$logso2, probs = .75)) +
                  (-.06081*quantile(pollution$loghc, probs = .75)),
                col  = "darkgreen") +
  annotate("text", x = 5, y = 6.9, label = "75th percentile",
           col = "darkgreen") +
    annotate("text", x = 5, y = 7.1, label = "25th percentile",
```

```
            col = "indianred") +
  geom_point(aes(x = pollution$lognox)) +
  labs(title = "logmort vs lognox",
       subtitle = "logso2, loghc at 25th, 50th, 75th percentiles",
       x = "lognox") +
  theme_classic()
```

logmort vs lognox
logso2, loghc at 25th, 50th, 75th percentiles
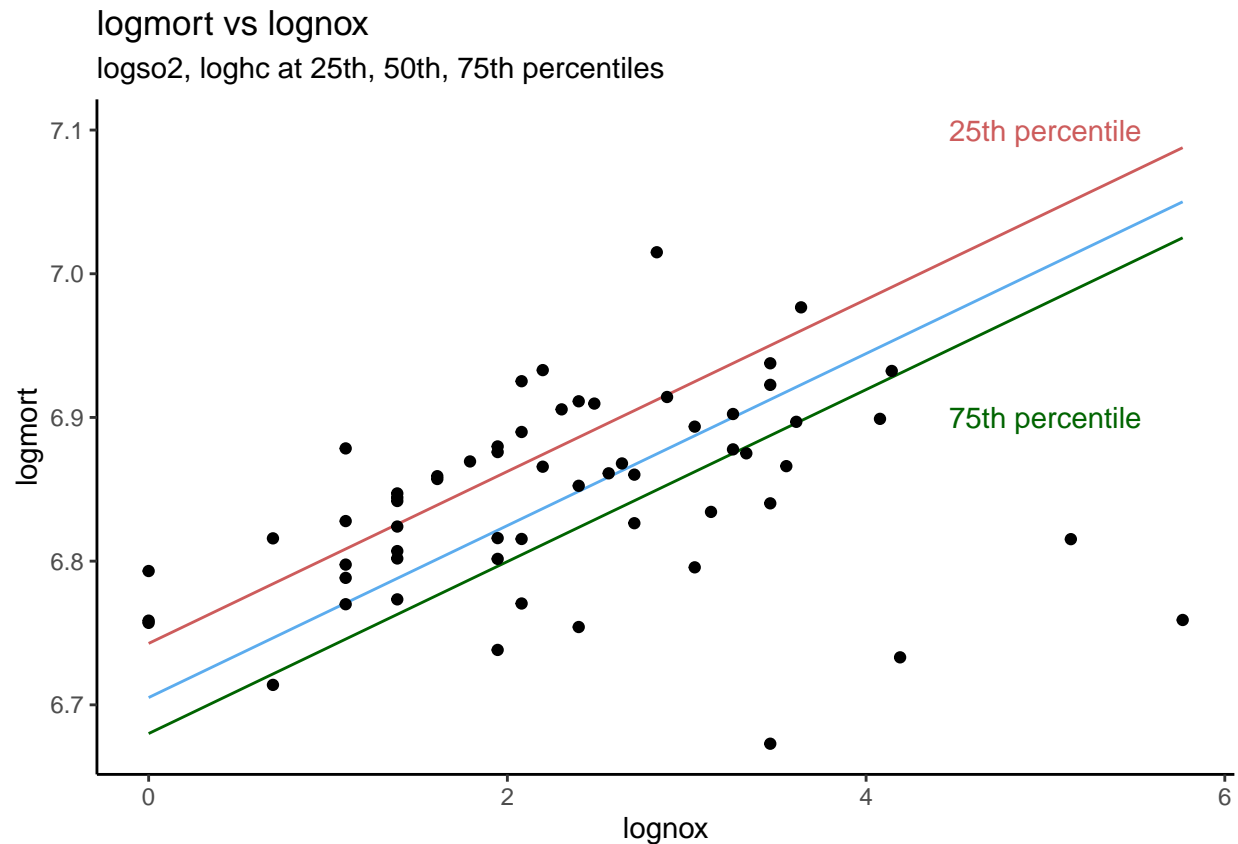

```
# showing regression table
```

```
stargazer(fit_all_log_y, type = "latex",
          title = "Regression Results Log Model")
```

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
% Date and time: Thu, Feb 25, 2021 - 11:16:18

The coefficient for lognox is .06. In context, this means that a 1% increase in nitric oxide levels is associated with a .06% increase in mortality rate, on average.

The coefficient for logso2 is .014. In context, this means that a 1% increase in so2 levels is associated with a .014% increase in mortality rate, on average.

the coefficient for loghc is -.061. In context, this means that a 1% increase in hc levels is associated with a .061% decrease in mortality rate, on average.

Table 1: Regression Results Log Model

	Dependent variable:
	logmort
lognox	0.060**
	(0.023)
logso2	0.014*
	(0.008)
loghc	−0.061***
	(0.021)
Constant	6.827***
	(0.023)
Observations	60
R^2	0.285
Adjusted R^2	0.247
Residual Std. Error	0.058 (df = 56)
F Statistic	7.449*** (df = 3; 56)
Note:	*p<0.1; **p<0.05; ***p<0.01

Part e

```r
# taking first 30 rows of data

pol_train <- pollution %>%
  head(30)

# taking last 30 rows of data

pol_test <- pollution %>%
  tail(30)

# fitting the training model

fit_all_log_y_train <- lm(logmort ~ lognox + logso2 + loghc, data = pol_train)

# creating predictions with test data

predictions <- predict(fit_all_log_y_train, newdata = pol_test)

pred_df <- cbind(predictions, pol_test)
```

The plot below shows the predicted values of logmort vs. the actual values of logmort from the second half of the data frame. The points to the left of the line are overpredictions and the points to the right of the line are underpredictions. From this plot, it appears that the predictions are relatively close to their true values, but the model overestimated more points than underestimated.

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```
pred_df %>%
  ggplot(aes(x = logmort, y = predictions)) +
  geom_point() +
  geom_abline(slope = 1, intercept = 0, col = "red") +
  labs(title = "Predicted vs Actual logmort",
       subtitle = "Line at predictions = logmort")
```

Predicted vs Actual logmort
Line at predictions = logmort
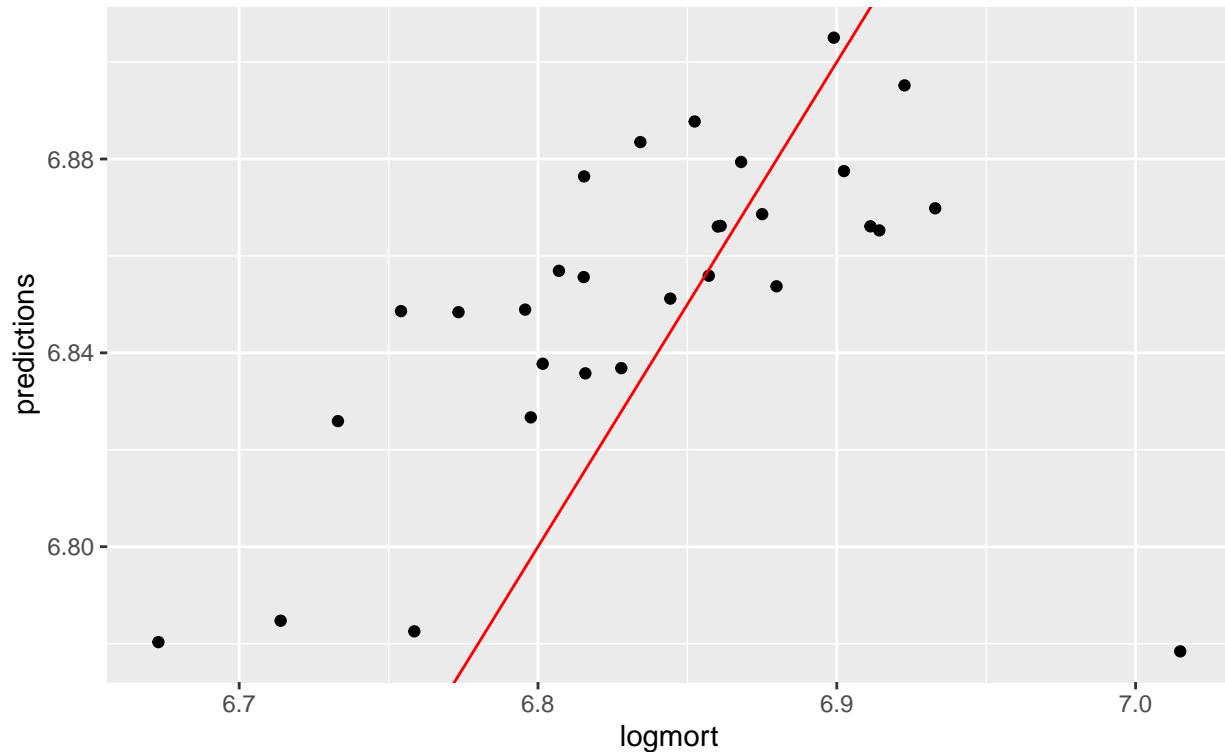

```
  theme_classic()
```

```
## List of 93
##  $ line                     :List of 6
##   ..$ colour       : chr "black"
##   ..$ size         : num 0.5
##   ..$ linetype     : num 1
##   ..$ lineend      : chr "butt"
##   ..$ arrow        : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
##  $ rect                     :List of 5
##   ..$ fill         : chr "white"
##   ..$ colour       : chr "black"
##   ..$ size         : num 0.5
##   ..$ linetype     : num 1
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
```

```
##  $ text                        :List of 11
##   ..$ family      : chr ""
##   ..$ face        : chr "plain"
##   ..$ colour      : chr "black"
##   ..$ size        : num 11
##   ..$ hjust       : num 0.5
##   ..$ vjust       : num 0.5
##   ..$ angle       : num 0
##   ..$ lineheight  : num 0.9
##   ..$ margin      : 'margin' num [1:4] 0points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ title                       : NULL
##  $ aspect.ratio                : NULL
##  $ axis.title                  : NULL
##  $ axis.title.x                :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 2.75points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.title.x.top            :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 0
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 2.75points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.title.x.bottom         : NULL
##  $ axis.title.y                :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : num 90
```

```
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 2.75points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.left       : NULL
## $ axis.title.y.right      :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : NULL
##   ..$ vjust        : num 0
##   ..$ angle        : num -90
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 0points 0points 2.75points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text               :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : chr "grey30"
##   ..$ size         : 'rel' num 0.8
##   ..$ hjust        : NULL
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : NULL
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x             :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : NULL
##   ..$ vjust        : num 1
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 2.2points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top         :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : NULL
```

```
##   ..$ vjust       : num 0
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 2.2points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom      : NULL
## $ axis.text.y             :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : num 1
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 2.2points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left        : NULL
## $ axis.text.y.right       :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : num 0
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 0points 2.2points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks              :List of 6
##   ..$ colour      : chr "grey20"
##   ..$ size        : NULL
##   ..$ linetype    : NULL
##   ..$ lineend     : NULL
##   ..$ arrow       : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ axis.ticks.x            : NULL
## $ axis.ticks.x.top        : NULL
## $ axis.ticks.x.bottom     : NULL
## $ axis.ticks.y            : NULL
## $ axis.ticks.y.left       : NULL
## $ axis.ticks.y.right      : NULL
## $ axis.ticks.length       : 'simpleUnit' num 2.75points
##   ..- attr(*, "unit")= int 8
```

```
##  $ axis.ticks.length.x       : NULL
##  $ axis.ticks.length.x.top   : NULL
##  $ axis.ticks.length.x.bottom: NULL
##  $ axis.ticks.length.y       : NULL
##  $ axis.ticks.length.y.left  : NULL
##  $ axis.ticks.length.y.right : NULL
##  $ axis.line                 :List of 6
##   ..$ colour     : chr "black"
##   ..$ size       : 'rel' num 1
##   ..$ linetype   : NULL
##   ..$ lineend    : NULL
##   ..$ arrow      : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
##  $ axis.line.x               : NULL
##  $ axis.line.x.top           : NULL
##  $ axis.line.x.bottom        : NULL
##  $ axis.line.y               : NULL
##  $ axis.line.y.left          : NULL
##  $ axis.line.y.right         : NULL
##  $ legend.background         :List of 5
##   ..$ fill       : NULL
##   ..$ colour     : logi NA
##   ..$ size       : NULL
##   ..$ linetype   : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
##  $ legend.margin             : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
##   ..- attr(*, "unit")= int 8
##  $ legend.spacing            : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
##  $ legend.spacing.x          : NULL
##  $ legend.spacing.y          : NULL
##  $ legend.key                : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##  $ legend.key.size           : 'simpleUnit' num 1.2lines
##   ..- attr(*, "unit")= int 3
##  $ legend.key.height         : NULL
##  $ legend.key.width          : NULL
##  $ legend.text               :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : 'rel' num 0.8
##   ..$ hjust      : NULL
##   ..$ vjust      : NULL
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : NULL
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ legend.text.align         : NULL
##  $ legend.title              :List of 11
```

```
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : num 0
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.align       : NULL
## $ legend.position          : chr "right"
## $ legend.direction         : NULL
## $ legend.justification     : chr "center"
## $ legend.box               : NULL
## $ legend.box.just          : NULL
## $ legend.box.margin        : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
## $ legend.box.background     : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing        : 'simpleUnit' num 11points
##   ..- attr(*, "unit")= int 8
## $ panel.background          :List of 5
##   ..$ fill        : chr "white"
##   ..$ colour      : logi NA
##   ..$ size        : NULL
##   ..$ linetype    : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ panel.border             : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ panel.spacing            : 'simpleUnit' num 5.5points
##   ..- attr(*, "unit")= int 8
## $ panel.spacing.x          : NULL
## $ panel.spacing.y          : NULL
## $ panel.grid               :List of 6
##   ..$ colour      : chr "grey92"
##   ..$ size        : NULL
##   ..$ linetype    : NULL
##   ..$ lineend     : NULL
##   ..$ arrow       : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ panel.grid.major         : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ panel.grid.minor         : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ panel.grid.major.x       : NULL
## $ panel.grid.major.y       : NULL
## $ panel.grid.minor.x       : NULL
## $ panel.grid.minor.y       : NULL
## $ panel.ontop              : logi FALSE
```

```
##  $ plot.background         :List of 5
##   ..$ fill         : NULL
##   ..$ colour       : chr "white"
##   ..$ size         : NULL
##   ..$ linetype     : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
##  $ plot.title              :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : 'rel' num 1.2
##   ..$ hjust        : num 0
##   ..$ vjust        : num 1
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 0points 5.5points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ plot.title.position     : chr "panel"
##  $ plot.subtitle           :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 0
##   ..$ vjust        : num 1
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 0points 5.5points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ plot.caption            :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : 'rel' num 0.8
##   ..$ hjust        : num 1
##   ..$ vjust        : num 1
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 5.5points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ plot.caption.position   : chr "panel"
##  $ plot.tag                :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
```

```
##   ..$ colour      : NULL
##   ..$ size        : 'rel' num 1.2
##   ..$ hjust       : num 0.5
##   ..$ vjust       : num 0.5
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ plot.tag.position        : chr "topleft"
## $ plot.margin              : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points
##   ..- attr(*, "unit")= int 8
## $ strip.background         :List of 5
##   ..$ fill        : chr "white"
##   ..$ colour      : chr "black"
##   ..$ size        : 'rel' num 2
##   ..$ linetype    : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ strip.background.x       : NULL
## $ strip.background.y       : NULL
## $ strip.placement          : chr "inside"
## $ strip.text               :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : chr "grey10"
##   ..$ size        : 'rel' num 0.8
##   ..$ hjust       : NULL
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 4.4points 4.4points 4.4points 4.4points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ strip.text.x             : NULL
## $ strip.text.y             :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : NULL
##   ..$ angle       : num -90
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ strip.switch.pad.grid    : 'simpleUnit' num 2.75points
##   ..- attr(*, "unit")= int 8
## $ strip.switch.pad.wrap    : 'simpleUnit' num 2.75points
```

```
##   ..- attr(*, "unit")= int 8
## $ strip.text.y.left        :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : NULL
##   ..$ angle       : num 90
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE
```