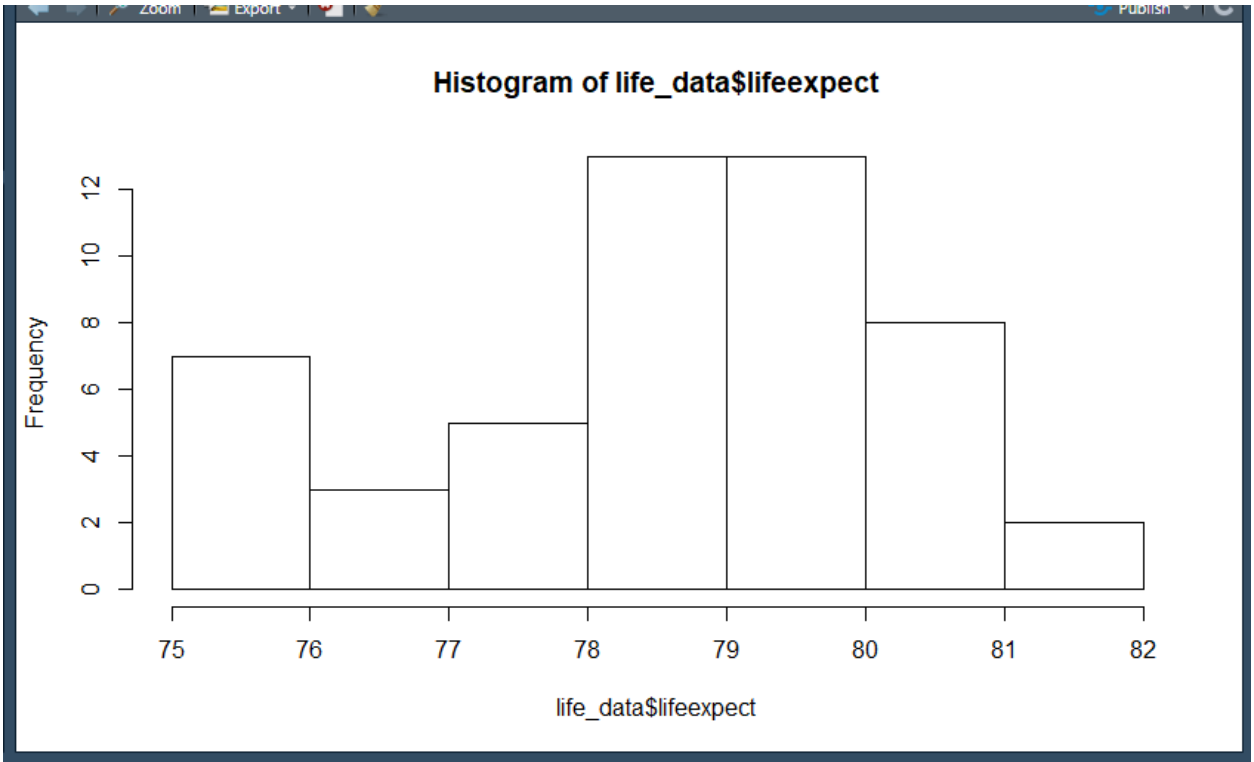
Douglas Stigler GEB 6895

Assignment 3 Due 10.09.2019

Question 1:

A)



11:08 PM

```
> # Inspect the data.
> summary(life_data)
       state      lifeexpect        medinc        uninsured         smoke          obesity         teenbirth
 Alabama   : 1   Min.   :75.00   Min.   :38.16   Min.   : 5.00   Min.   : 9.40   Min.   :21.00   Min.   :15.70
 Alaska    : 1   1st Qu.:77.70   1st Qu.:44.63   1st Qu.:11.70   1st Qu.:16.45   1st Qu.:26.00   1st Qu.:27.35
 Arizona   : 1   Median :78.80   Median :49.02   Median :13.80   Median :18.10   Median :27.00   Median :33.00
 Arkansas  : 1   Mean   :78.62   Mean   :50.02   Mean   :14.25   Mean   :18.49   Mean   :27.65   Mean   :34.23
 California: 1   3rd Qu.:79.90   3rd Qu.:55.57   3rd Qu.:16.65   3rd Qu.:20.55   3rd Qu.:30.00   3rd Qu.:41.65
 Colorado  : 1   Max.   :81.30   Max.   :66.63   Max.   :24.80   Max.   :26.00   Max.   :35.00   Max.   :55.00
 (Other)   :45
     gunlaw           metro
 Min.   :0.0000   Min.   : 29.66
 1st Qu.:0.0000   1st Qu.: 63.20
 Median :0.0000   Median : 74.88
 Mean   :0.4118   Mean   : 74.01
 3rd Qu.:1.0000   3rd Qu.: 87.78
 Max.   :1.0000   Max.   :100.00
```

	state	lifeexpect	medinc	uninsured	smoke	obesity	teenbirth	gunlaw	metro
1	Alabama	75.4	40.933	14.4	21.9	33	43.6	0	71.46
2	Alaska	78.3	57.848	18.3	20.8	27	38.3	0	67.36
3	Arizona	79.6	46.896	19.1	16.6	26	41.9	0	92.53
4	Arkansas	76.0	38.587	18.5	22.4	31	52.5	0	60.27
5	California	80.8	54.283	18.9	12.9	25	31.5	1	97.73
6	Colorado	80.0	60.233	14.3	16.9	21	33.4	0	86.33
7	Connecticut	80.8	65.998	10.5	14.9	22	18.7	1	91.37
8	Delaware	78.4	55.214	11.7	18.0	28	30.5	1	78.04
9	D.C.	76.5	56.928	11.4	15.7	22	45.4	0	100.00
10	Florida	79.4	44.966	20.7	18.0	26	33.0	1	84.09

There does not appear to be any issues with the data for the purpose of building a linear regression model.

B)

```
Call:
lm(formula = lifeexpect ~ medinc + uninsured + smoke + obesity +
    teenbirth + gunlaw + metro, data = life_data)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7711 -0.3769 -0.1080  0.4822  1.3171

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 89.735528   2.251922  39.848  < 2e-16 ***
medinc      -0.010854   0.022245  -0.488 0.628090
uninsured    0.045937   0.036861   1.246 0.219422
smoke       -0.221999   0.050253  -4.418 6.64e-05 ***
obesity     -0.126588   0.050311  -2.516 0.015679 *
teenbirth   -0.078177   0.018433  -4.241 0.000116 ***
gunlaw       0.484511   0.250156   1.937 0.059353 .
metro       -0.015507   0.006564  -2.363 0.022747 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6722 on 43 degrees of freedom
Multiple R-squared:  0.8602,    Adjusted R-squared:  0.8375
F-statistic: 37.81 on 7 and 43 DF,  p-value: 2.315e-16
```

The variables that appear to have explanitory power are smoke, obesity, teenbirth, and metro because of the values of significance within 5%. The other variables (medinc, unisured, and gunlaw) would be good canadiates for omissin in the model.

C)

```
################################################
# Removing one variable at a time from full model
################################################

#Model without medinc variables
life_a_model <- lm(data = life_data,
                   formula = lifeexpect ~ uninsured + smoke + obesity + teenbirth + gunlaw + metro)
#Summarize a model
summary(life_a_model)

###################

#Model without uninsured variables
life_b_model <- lm(data = life_data,
                   formula = lifeexpect ~ medinc + smoke + obesity + teenbirth + gunlaw + metro)

#Summarize b model
summary(life_b_model)

###################


#Model without gunlaw variables
life_c_model <- lm(data = life_data,
                   formula = lifeexpect ~ medinc + uninsured + smoke + obesity + teenbirth  + metro)

#Summarize c model
summary(life_c_model)

###################
```

Removing one variable at a time all have different inpacts in the adjusted R^2, dpeending on which variable. Medinc being removed moves the adjusted R^2 closer to 1, while removing uninsured and gunlaw each move adjusted R^2 closer to 0.

D)

```
################################################
# Removing variables from full model
################################################

#Model with -1 variables
life_d_model <- lm(data = life_data,
                     formula = lifeexpect ~ uninsured + smoke + obesity + teenbirth + gunlaw + metro)
#Summarize -1 model
summary(life_d_model)

###################

#Model with -2 variables
life_e_model <- lm(data = life_data,
                   formula = lifeexpect ~ smoke + obesity + teenbirth + gunlaw + metro)

#Summarize -2 model
summary(life_e_model)

###################


#Model with -3 variables
life_f_model <- lm(data = life_data,
                   formula = lifeexpect ~ smoke + obesity + teenbirth  + metro)

#Summarize -3 model
summary(life_f_model)

###################


#Model with -4 variables
life_g_model <- lm(data = life_data,
                   formula = lifeexpect ~ smoke + obesity + teenbirth)

#Summarize -4 model
summary(life_g_model)

###################
```

Removing one non-significant to 5% variable at time causes the metro variable to become non-significant to 5% during the process. After removing the non-significant variables all estimates were like the original model with reduced std. deviations in some cases.

Original:

```
Call:
lm(formula = lifeexpect ~ medinc + uninsured + smoke + obesity +
    teenbirth + gunlaw + metro, data = life_data)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7711 -0.3769 -0.1080  0.4822  1.3171

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 89.735528   2.251922  39.848  < 2e-16 ***
medinc      -0.010854   0.022245  -0.488 0.628090
uninsured    0.045937   0.036861   1.246 0.219422
smoke       -0.221999   0.050253  -4.418 6.64e-05 ***
obesity     -0.126588   0.050311  -2.516 0.015679 *
teenbirth   -0.078177   0.018433  -4.241 0.000116 ***
gunlaw       0.484511   0.250156   1.937 0.059353 .
metro       -0.015507   0.006564  -2.363 0.022747 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6722 on 43 degrees of freedom
Multiple R-squared:  0.8602,    Adjusted R-squared:  0.8375
F-statistic: 37.81 on 7 and 43 DF,  p-value: 2.315e-16

>
```

With variables removed:

```
Call:
lm(formula = lifeexpect ~ smoke + obesity + teenbirth, data = life_data)

Residuals:
    Min      1Q  Median      3Q     Max
-2.5115 -0.3408 -0.0091  0.3743  1.3860

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 87.95101    0.89483  98.287  < 2e-16 ***
smoke       -0.20643    0.04932  -4.186 0.000124 ***
obesity     -0.11023    0.04855  -2.271 0.027802 *
teenbirth   -0.07210    0.01279  -5.638 9.47e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7051 on 47 degrees of freedom
Multiple R-squared:  0.8319,    Adjusted R-squared:  0.8212
F-statistic: 77.52 on 3 and 47 DF,  p-value: < 2.2e-16

>
```

E) Using another approach by adding variables one at a time, I concluded that the full model would be the best. This is because the adjusted R^2 was the greatest in that model compared to my others. This was likely due to the way I chose to add variables and I could have arrived at a different outcome had I added the variables in a different order. Comparing the full model recommendation derived from adding one variable at a time versus the variable removal method, I choose to base my recommendation off the adjusted R^2 value, so I would recommend the model with only the medinc variable removed. If you were choosing the recommendation off T values, P values, or only having variables within a 5% level of significance than a different model may be recommended.

Recommended:

```
Call:
lm(formula = lifeexpect ~ uninsured + smoke + obesity + teenbirth +
    gunlaw + metro, data = life_data)

Residuals:
     Min       1Q   Median       3Q      Max
-1.78062 -0.42901 -0.06467  0.45527  1.30810

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 88.78329    1.11369  79.720  < 2e-16 ***
uninsured    0.04979    0.03569   1.395 0.170069
smoke       -0.21763    0.04902  -4.440 5.98e-05 ***
obesity     -0.11707    0.04597  -2.547 0.014453 *
teenbirth   -0.07676    0.01804  -4.254 0.000108 ***
gunlaw       0.46849    0.24583   1.906 0.063235 .
metro       -0.01593    0.00645  -2.470 0.017477 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6663 on 44 degrees of freedom
Multiple R-squared:  0.8595,    Adjusted R-squared:  0.8403
F-statistic: 44.85 on 6 and 44 DF,  p-value: < 2.2e-16
```

Full Model:

```
Call:
lm(formula = lifeexpect ~ medinc + uninsured + smoke + obesity +
    teenbirth + gunlaw + metro, data = life_data)

Residuals:
    Min      1Q  Median      3Q     Max
-1.7711 -0.3769 -0.1080  0.4822  1.3171

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 89.735528   2.251922  39.848  < 2e-16 ***
medinc      -0.010854   0.022245  -0.488 0.628090
uninsured    0.045937   0.036861   1.246 0.219422
smoke       -0.221999   0.050253  -4.418 6.64e-05 ***
obesity     -0.126588   0.050311  -2.516 0.015679 *
teenbirth   -0.078177   0.018433  -4.241 0.000116 ***
gunlaw       0.484511   0.250156   1.937 0.059353 .
metro       -0.015507   0.006564  -2.363 0.022747 *
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6722 on 43 degrees of freedom
Multiple R-squared:  0.8602,    Adjusted R-squared:  0.8375
F-statistic: 37.81 on 7 and 43 DF,  p-value: 2.315e-16
```

Only significant variables:

```
Call:
lm(formula = lifeexpect ~ smoke + obesity + teenbirth, data = life_data)

Residuals:
    Min      1Q  Median      3Q     Max
-2.5115 -0.3408 -0.0091  0.3743  1.3860

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 87.95101    0.89483  98.287  < 2e-16 ***
smoke       -0.20643    0.04932  -4.186 0.000124 ***
obesity     -0.11023    0.04855  -2.271 0.027802 *
teenbirth   -0.07210    0.01279  -5.638 9.47e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7051 on 47 degrees of freedom
Multiple R-squared:  0.8319,    Adjusted R-squared:  0.8212
F-statistic: 77.52 on 3 and 47 DF,  p-value: < 2.2e-16

>
```

Question 2:

A) There do not appear to be any problems with this data. The dependent variable is binary representing each of the hospitals with a 1 or 0.

```
> # Inspect the data.
> summary(hospital_data)
      OBS               D              DISTANCE          INCOME          OLD        
 Min.   :  1.0   Min.   :0.0000   Min.   :-3.746   Min.   :41.12   Min.   :0.0000  
 1st Qu.:125.5   1st Qu.:0.0000   1st Qu.:-3.412   1st Qu.:43.40   1st Qu.:1.0000  
 Median :250.0   Median :1.0000   Median :-1.970   Median :44.39   Median :1.0000  
 Mean   :250.0   Mean   :0.7295   Mean   :-1.011   Mean   :45.71   Mean   :0.8377  
 3rd Qu.:374.5   3rd Qu.:1.0000   3rd Qu.: 1.570   3rd Qu.:47.93   3rd Qu.:1.0000  
 Max.   :499.0   Max.   :1.0000   Max.   : 3.765   Max.   :55.17   Max.   :1.0000  
> 
```

Filter

	OBS	D	DISTANCE	INCOME	OLD
1	1	1	3.00000	42.24318	0
2	2	0	-3.74610	43.41784	1
3	3	0	-3.74610	43.41784	1
4	4	0	-3.73690	43.82044	0
5	5	1	-3.73690	43.43426	1
6	6	1	-3.71620	42.68955	1
7	7	1	-3.70920	44.05817	1
8	8	1	-3.70920	44.27197	0
9	9	1	-3.70920	44.05817	1
10	10	1	-3.70920	44.05817	1
11	11	1	-3.70920	44.05817	1
12	12	1	-3.70920	44.05817	1

B) After building the initial linear model, it would appear that DISTANCE is the only significant variable within 5%.

```
#####################################################
# Full Linear Model
#####################################################

#Model with all variables
life_linear_model <- lm(data = hospital_data,
                        formula = D ~ DISTANCE + INCOME + OLD)

#Summarize full model
summary(life_linear_model)
```

```
Call:
lm(formula = D ~ DISTANCE + INCOME + OLD, data = hospital_data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.98891 -0.34933  0.07475  0.19036  0.66563

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.193452   0.297168   4.016 6.84e-05 ***
DISTANCE    -0.071995   0.007601  -9.471  < 2e-16 ***
INCOME      -0.010807   0.006257  -1.727   0.0848 .
OLD         -0.051046   0.048009  -1.063   0.2882
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3922 on 495 degrees of freedom
Multiple R-squared:  0.2267,    Adjusted R-squared:  0.222
F-statistic: 48.36 on 3 and 495 DF,  p-value: < 2.2e-16
```

C)

```
##################################################
# Full Logistic Model
##################################################

#Model with all variables
life_log_model <- glm(data = hospital_data,
                      formula = D ~ DISTANCE + INCOME + OLD)

#Summarize full model
summary(life_log_model)
```

```
Call:
lm(formula = D ~ DISTANCE + INCOME + OLD, data = hospital_data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.98891 -0.34933  0.07475  0.19036  0.66563

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.193452   0.297168   4.016 6.84e-05 ***
DISTANCE    -0.071995   0.007601  -9.471  < 2e-16 ***
INCOME      -0.010807   0.006257  -1.727   0.0848 .
OLD         -0.051046   0.048009  -1.063   0.2882
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3922 on 495 degrees of freedom
Multiple R-squared:  0.2267,    Adjusted R-squared:  0.222
F-statistic: 48.36 on 3 and 495 DF,  p-value: < 2.2e-16
```