Problem Set 1 Report

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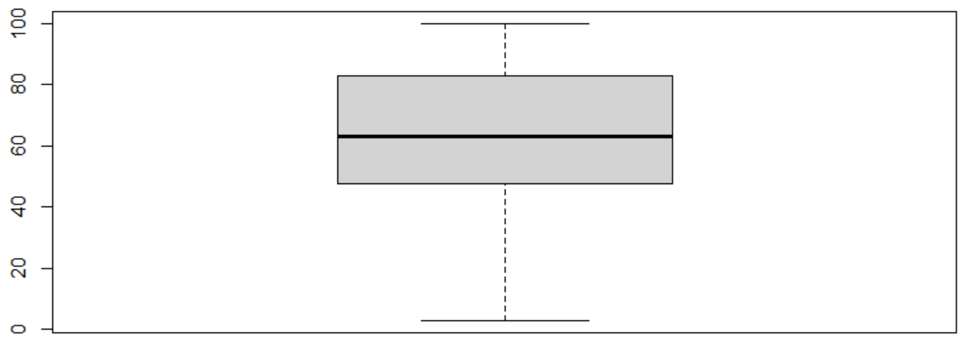
1. Scores

a. Summary statistics for scores, including min, max, sample mean, sample variance, sample standard deviation, coefficient of variation, mean absolute deviation, Q1, median, Q3, and IQR. Results are presented on well-formatted table with a title.

Statistics name	**Value**
Min	3
Max	100
Sample Mean	62.37
Sample Variance	546.033266
Standard Deviation	23.3673547
Coefficient of Variance	0.37465696
Mean Average Deviation	18.6863
Interquartile Range (IQR)	35.25

Summary Statistics for Scores

b. Box and whisker plot for score (on next page).

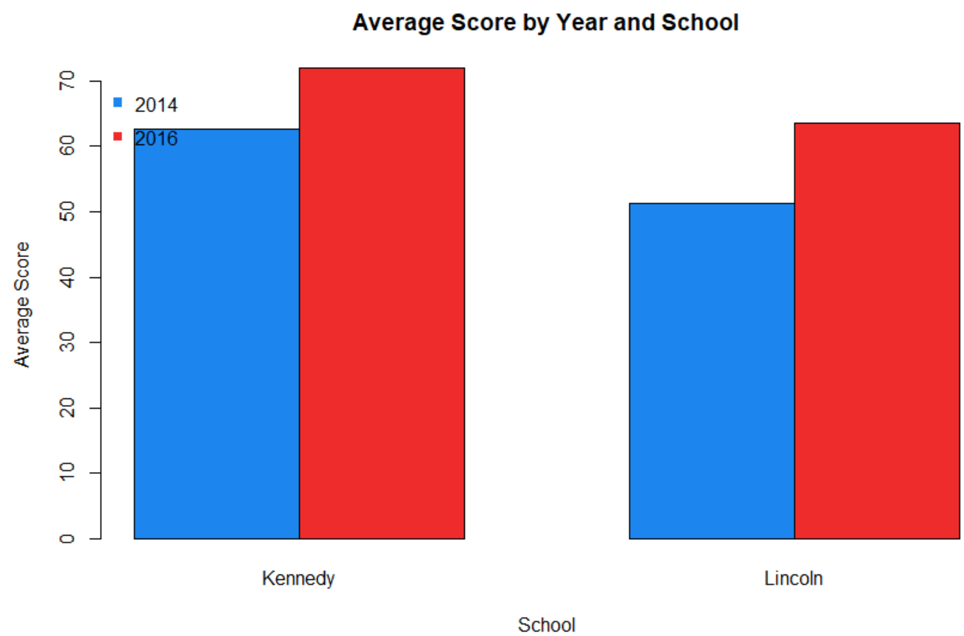


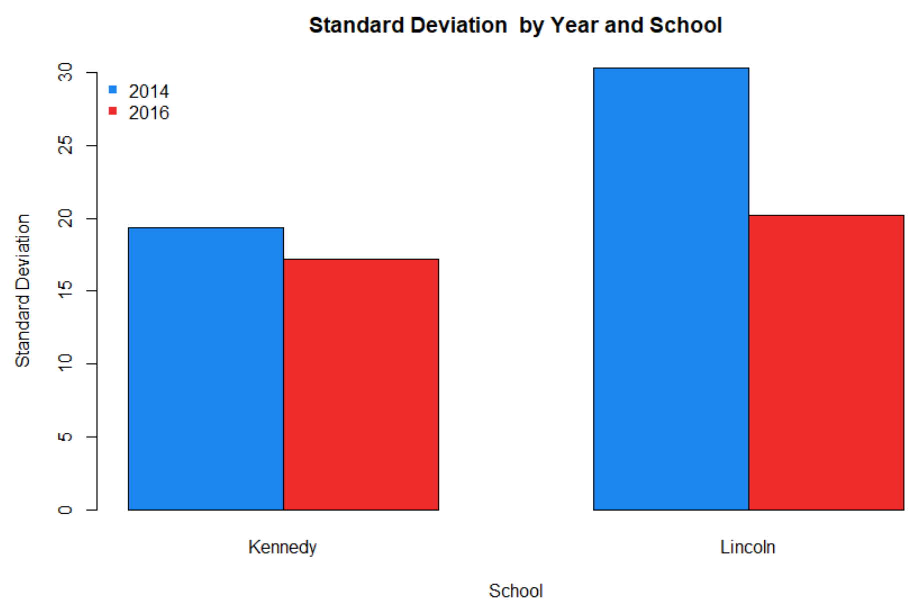
Box and whisker plot for Scores

c. Summary for scores by year and by school, including sample mean and sample standard deviation. Statistics are presented on a well-formatted table and a bar chart diagram.

Year	**School**	**Sample Mean**	**Sample Standard Deviation**
2014	Kennedy	62.58	19.36765
2016	Kennedy	71.96	17.19748
2014	Lincoln	51.32	30.30285
2016	Lincoln	63.62	20.20799

Summary Statistic for Scores, aggregated by Year and School





d. School Comparison:
Based on the numerical data we get, in both years Kennedy High School has a better average score than Lincoln High School, which can indicate a better academic achievement of the students in Kennedy High School. It is also worth noting here that both schools have larger average scores in 2016 than in 2014, which suggests an improvement over the scores from 2014 to 2016 in both schools. Regarding the Standard Deviation, the scores in Lincoln High School have a larger Standard Deviation, which suggests a higher dispersion in the scores

of the school. It also means that there is a bigger difference in the academic performance of students at Lincoln High school than that of Kennedy School. In terms of trend, both schools features lower standard deviation in 2016, indicating that the students became to have a more similar performances to each other.

2. **Medical Expenses**
   a. Summary statistics for all numeric variables, including min, max, sample mean, sample variance, sample standard deviation, coefficient of variation, mean absolute deviation, Q1, median, Q3, and IQR. The results are presented on a well-formatted table with a title.

Statistics name	**Values**
Medical Expenses - Min	1
Medical Expenses - Max	62.231
Medical Expenses - Sample Mean	19.18752
Medical Expenses - Sample Variance	201.7416
Medical Expenses - sample standard deviation	14.20358
Medical Expenses - coefficient of variation	0.740251
Medical Expenses - mean absolute deviation	11.62128
Medical Expenses - Q1	8.208
Medical Expenses - median	16.351
Medical Expenses - Q3	26.822
Medical Expenses - IQR	18.614
Income - Min	4
Income - Max	99
Income - Sample Mean	37.42353
Income - Sample Variance	399.4613
Income - sample standard deviation	19.98653
Income - coefficient of variation	0.534063
Income - mean absolute deviation	15.87017
Income - Q1	21
Income - median	34
Income - Q3	48
Income - IQR	27
Education - Min	0
Education - Max	18
Education - Sample Mean	10.17647

Education - Sample Variance	22.33754
Education - sample standard deviation	4.72626
Education - coefficient of variation	0.46443
Education - mean absolute deviation	3.9391
Education - Q1	6
Education - median	11
Education - Q3	13
Education - IQR	7

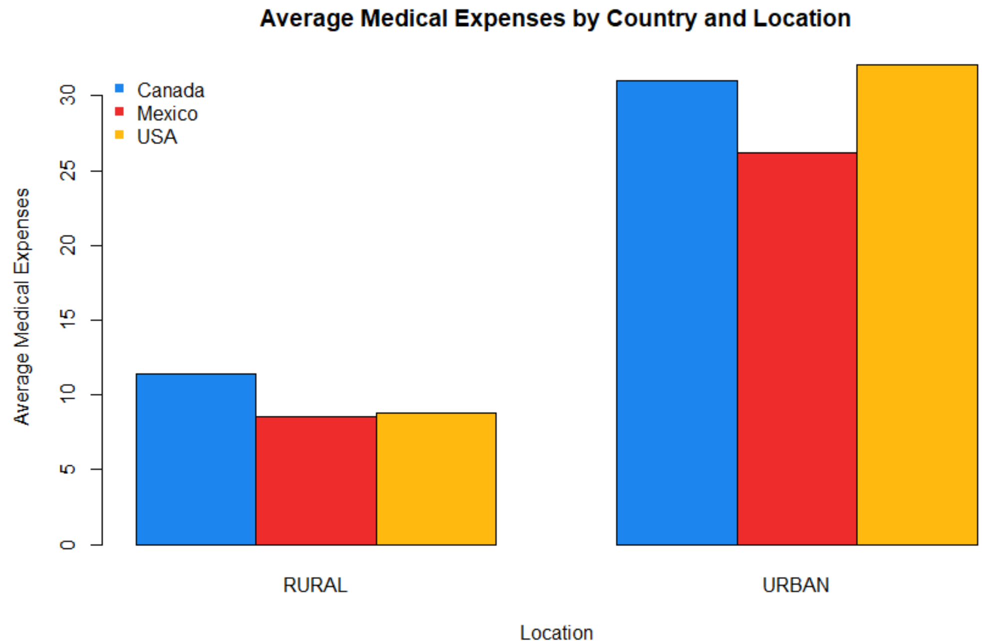
Summary Statistics for Scores

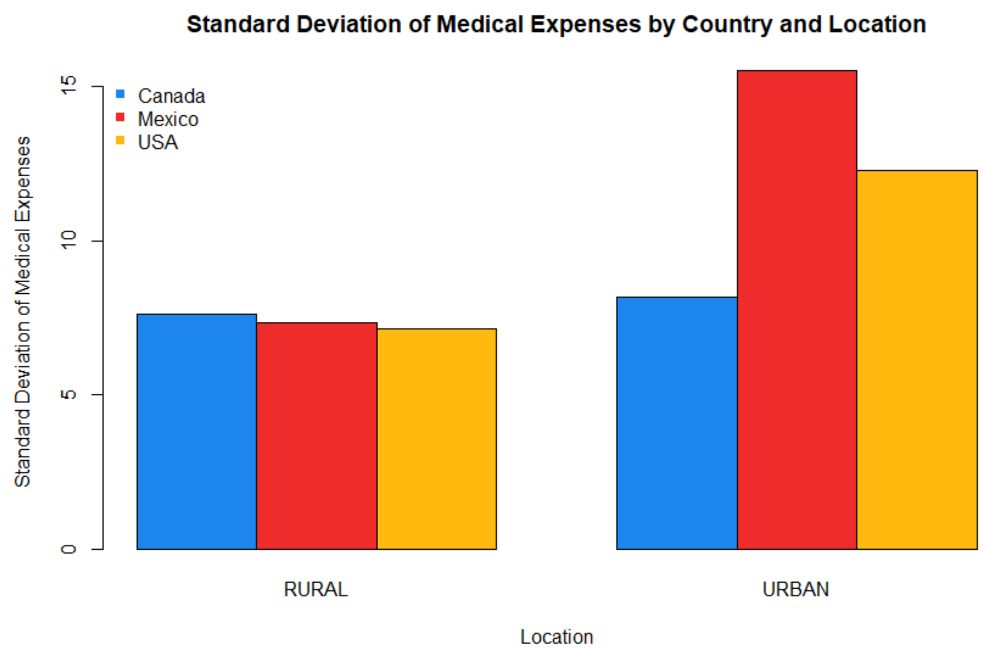
b. Outlier identification for medical expenses:
Based on the data we got (in the R code), the Interquartile Range (IQR) of medical expenses is 18.164 (unit: $100). Based on the definition that the outliers are data points outside the range of $[Q1 - 1.5IQR, Q3 + 1.5IQR]$, we get the outlier is the value 62.231 of row 27 (or row 28 if we do take into account the first row containing the names of the fields).

c. Summary statistics for all numeric variables, including Sample Mean and Sample Standard Deviation, by country and by location (urban/rural). The results are presented in well-formatted tables and bar chart diagrams.

Country	**Location**	**Medical Expenses - Sample Mean**	**Medical Expenses - Sample Standard Deviation**
CANADA	RURAL	11.43058	7.629464
MEXICO	RURAL	8.512818	7.324204
USA	RURAL	8.7616	7.132344
CANADA	URBAN	31.00309	8.175206
MEXICO	URBAN	26.19179	15.517216
USA	URBAN	32.06493	12.288999

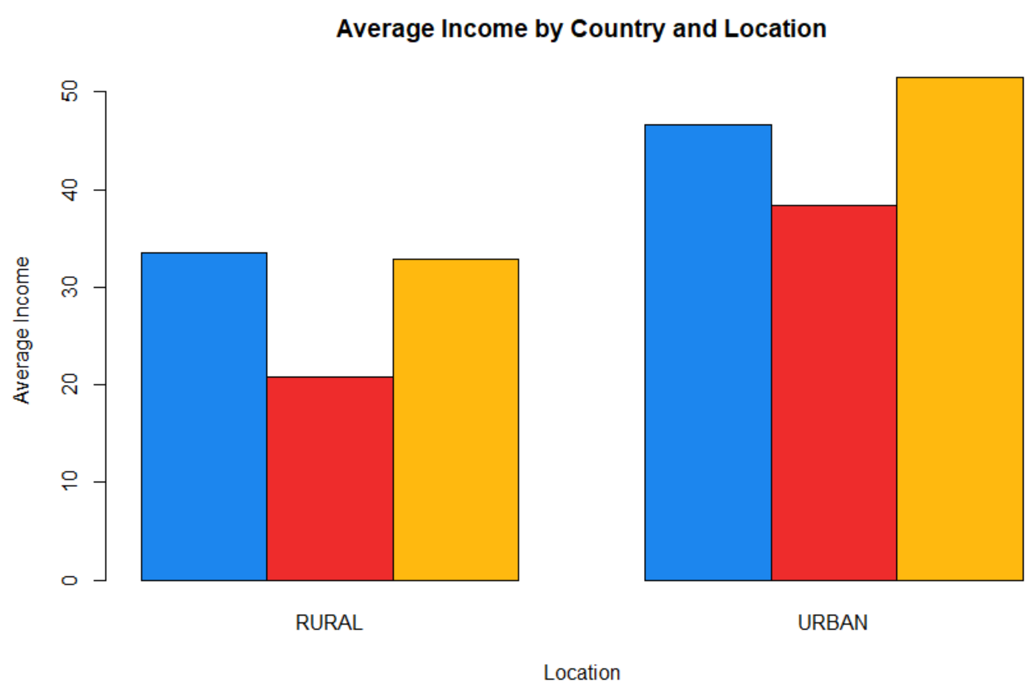
Summary Statistics for Medical Expenses

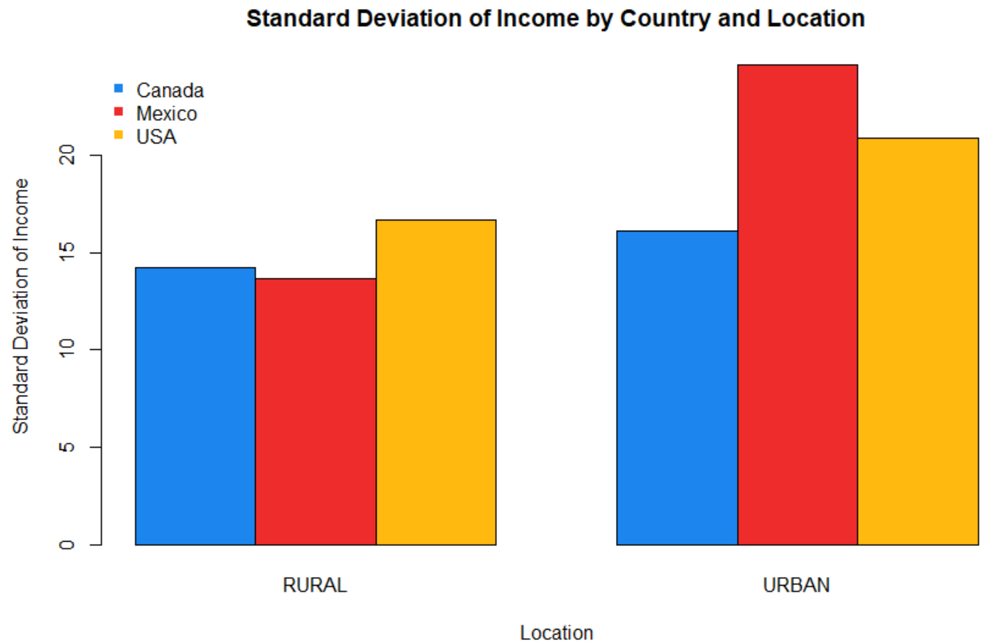

Average Medical Expenses by Country and Location
Canada
Mexico
USA
Average Medical Expenses
0
5
10
15
20
25
30
RURAL
URBAN
Location


Standard Deviation of Medical Expenses by Country and Location
Canada
Mexico
USA
Standard Deviation of Medical Expenses
0
5
10
15
RURAL
URBAN
Location

Country	Location	Income - Sample Mean	Income - Sample Standard Deviation
CANADA	RURAL	33.47368	14.23754
MEXICO	RURAL	20.81818	13.65883
USA	RURAL	32.93333	16.69246
CANADA	URBAN	46.63636	16.13241
MEXICO	URBAN	38.35714	24.65019
USA	URBAN	51.46667	20.87674

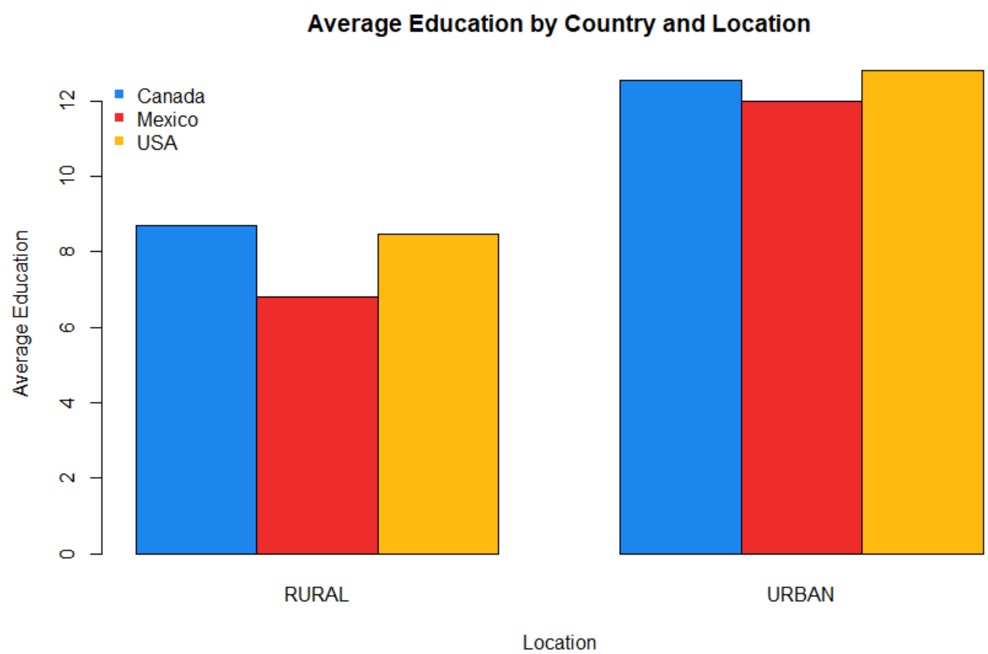
Summary Statistics for Income

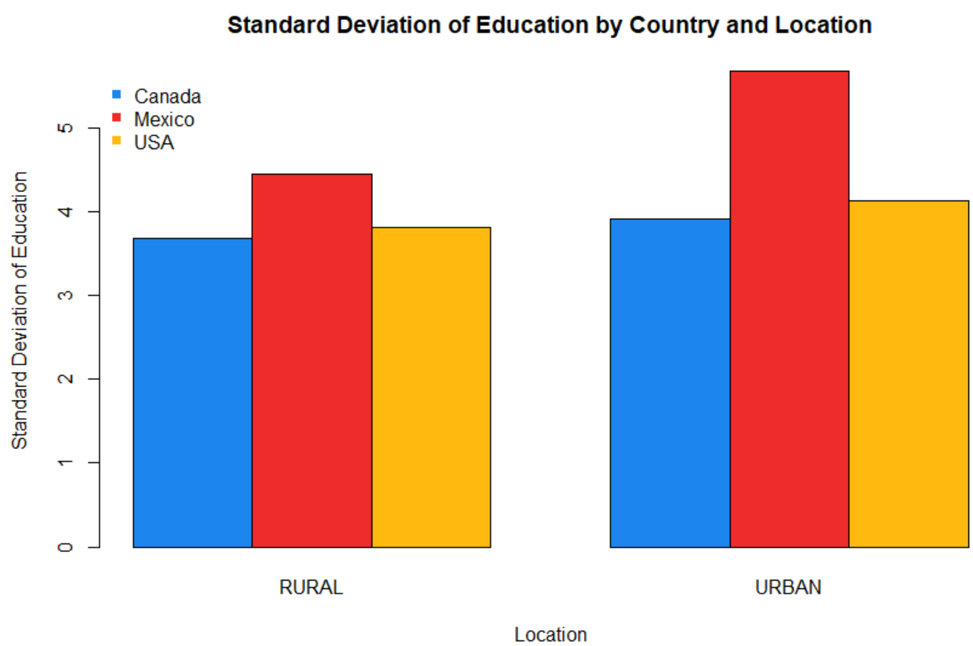




Country	Location	Education - Sample Mean	Education - Sample Standard Deviation
CANADA	RURAL	8.684211	3.682581
MEXICO	RURAL	6.818182	4.445631
USA	RURAL	8.466667	3.814758
CANADA	URBAN	12.54546	3.908034
MEXICO	URBAN	12	5.670436
USA	URBAN	12.8	4.126569

Summary Statistics for Education





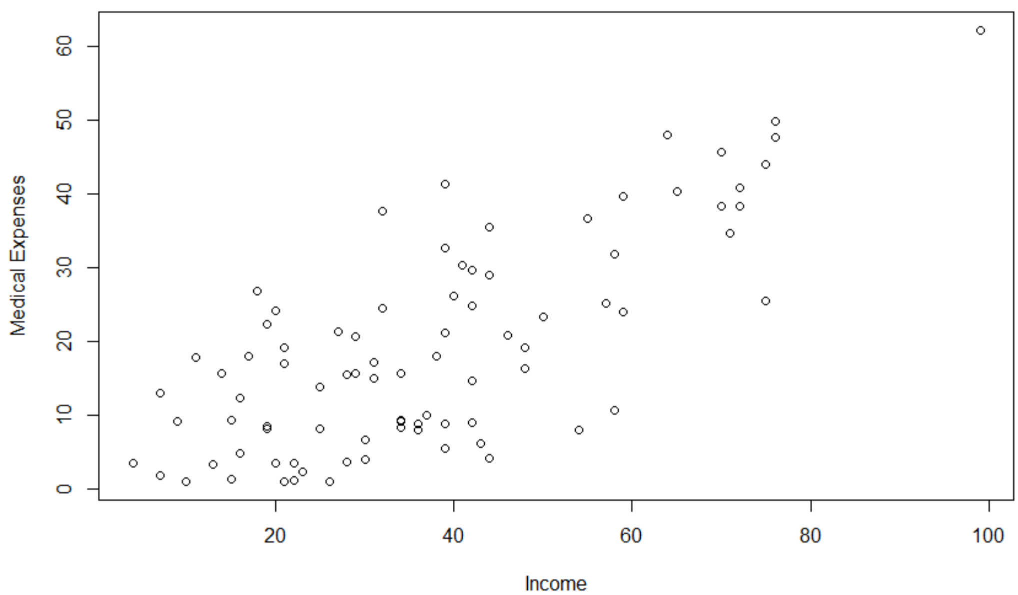
d. Comparison among countries and locations:
Firstly, for medical expenses, the average values in urban households are significantly higher than that of rural households (in respective countries). Canada and USA have a higher average value than Mexico. Regarding the standard deviation, the three countries have a relatively similar standard deviation for the rural areas. It is noteworthy that for the urban areas, Mexico has a significantly

higher standard deviation compared to the other two countries, indicating highly differentiated medical expenses among their urban households.

A similar fashion can be found in the income data. The urban areas have significantly higher average incomes than their rural counterparts. Canada and USA have a higher average income than Mexico. However, Mexico has a significantly higher standard deviation, indicating highly dispersed income data points in their urban citizens.

In terms of education, the urban areas also have higher average education than the rural areas. Canada and USA also lead in the average education. Mexico has a significantly high standard deviation in both its rural and urban areas, which implies a relatively large difference in the level of education among Mexican households.

e. Medical Expenses and Income



Scatter plot of Medical Expenses and Income

Scatter plot inference: From the Scatter plot, we can infer that the majority of medical expenses are less than \$5,000, and the majority of the income is less than \$80,000. There is one outlier with medical expenses of approximately \$6,000 and income of nearly \$100,000, which has been reported in part B. We can also observe a relatively positively linear relationship between medical expenses and income, where the income increases with medical expenses and vice versa. This relationship will be further explored in part F below.

f. Sample correlations between all numeric variables and present them in a table.

	Medical Expenses	**Income**	**Education**
Medical Expenses	1	0.748268	0.689534
Income	0.748268	1	0.684411
Education	0.689534	0.684411	1

Sample Correlations among Medical Expenses, Income, and Education

Firstly, regarding the medical expenses and income, we can observe that they have a correlation of 0.75, which is positive and relatively close to 1, indicating a strong positive linear association between the two variables. It means that as income increases, we can observe a proportional increase in medical expenses and vice versa.

In terms of medical expenses and education, we can also see a relatively strong positive linear correlation between the two variables, with a correlation of 0.69, which is positive and close to 1. This also indicates an observation that as medical expenses increase, there is also an increase in education and vice versa.

Lastly, the relationship between income and education also follows a similar fashion, with a correlation of 0.68, implying a strong positive linear association, as it is positive and relatively close to 1. It means that income and education are observed to grow proportionally to each other.

In conclusion, the correlation values suggest a strong positive linear association among the three variables.

Addendum

Project Repository: https://github.com/MykeDuong/econ453

R Script code:

```
# Minh Duong, ECON 453, pset 1

# Packages Install && Import
library(readxl)

# Clear workspace
rm(list = ls())

# Relative directory
# Put data to the data directory inside the project directory
setwd(".")
getwd()

# Problem 1
data1<- read_excel("data/pset1_data.xlsx", sheet="scores")

summary(data1)

## 1A
# Add necessary summary statistics:
summary(data1)
data1_summary <- as.data.frame(
  apply(data1, 2, summary)
)
data1_summary
data1_summary = rbind(
  min(data1$score),
  max(data1$score),
  mean(data1$score),
  var(data1$score),
  sd(data1$score),
  sd(data1$score) / mean(data1$score),
  mean(abs(data1$score - mean(data1$score))),
  IQR(data1$score)
)

# Provide Row names
rownames(data1_summary) <- c(
  "Min",
  "Max",
  "Sample Mean",
  "Sample Variance",
  "Standard Deviation",
  "Coefficient of Variance",
  "Mean Average Deviation",
  "Interquartile Range (IQR)"
)
```

```
colnames(data1_summary) <- c(
  "Value"
)

# Report the table:
data1_summary

write.csv(data1_summary, "exports/data1_summary.csv", row.names = TRUE)

# 1B
boxplot(data1$score)

# 1C
# Sample Mean, Sample SD aggregated by year & school
aggregated_data1 = aggregate(
  data1$score,
  list(
    Year = data1$year,
    School = data1$school
  ),
  FUN = function(x) c(
    "Sample Mean" = mean(x),
    "Sample SD" = sd(x)
  )
)

aggregated_data1


write.csv(aggregated_data1,
"exports/aggregated_data1_by_school_and_year.csv", row.names = TRUE)

# Bar Chart Draw
# Sample Mean Chart
barplot(
  x[,"Sample Mean"] ~ Year + School,
  data = aggregated_data1,
  beside = T,
  col = c("dodgerblue2", "firebrick2"),
  main = "Average Score by Year and School",
  ylab = "Average Score",
  xlab = "School"
)

legend(
  "topleft",
  c("2014", "2016"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2")
)
```

```
# Standard Deviation Chart
barplot(
  x[,"Sample SD"] ~ Year + School ,
  data = aggregated_data1,
  beside = T,
  col = c("dodgerblue2", "firebrick2"),
  main = "Standard Deviation  by Year and School",
  ylab = "Standard Deviation",
  xlab = "School"
)

legend(
  "topleft",
  c("2014", "2016"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2")
)

# Question 2
data2<- read_excel("data/pset1_data.xlsx", sheet="medical_expenses");

# 2A
summary(data2)

data2_summary <- as.data.frame(
  apply(data2, 2, summary)
)

data2_summary

data2_summary = rbind(
  # Medical Experience
  min(data2$medicalexpn), # Min
  max(data2$medicalexpn), # Max
  mean(data2$medicalexpn),# Mean
  var(data2$medicalexpn), # Variance
  sd(data2$medicalexpn), # Standard Deviation
  sd(data2$medicalexpn) / mean(data2$medicalexpn), # Co. of Variation
  mean(abs(data2$medicalexpn - mean(data2$medicalexpn))), # Mean abs.
Deviation
  quantile(data2$medicalexpn, 0.25), # 1st Quartile
  quantile(data2$medicalexpn, 0.5), # Median
  quantile(data2$medicalexpn, 0.75), # 3rd Quartile
  IQR(data2$medicalexpn), # Interquartile Range

  # Income
  min(data2$income),
  max(data2$income),
  mean(data2$income),
  var(data2$income),
  sd(data2$income),
  sd(data2$income) / mean(data2$income),
```

```
  mean(abs(data2$income - mean(data2$income))),
  quantile(data2$income, 0.25),
  quantile(data2$income, 0.5),
  quantile(data2$income, 0.75),
  IQR(data2$income),

  # Education
  min(data2$education),
  max(data2$education),
  mean(data2$education),
  var(data2$education),
  sd(data2$education),
  sd(data2$education) / mean(data2$education),
  mean(abs(data2$education - mean(data2$education))),
  quantile(data2$education, 0.25),
  quantile(data2$education, 0.5),
  quantile(data2$education, 0.75),
  IQR(data2$education)
)


# Provide Row names
rownames(data2_summary) <- c(
  # Medical Experience
  "Medical Expenses - Min",
  "Medical Expenses - Max",
  "Medical Expenses - Sample Mean",
  "Medical Expenses - Sample Variance",
  "Medical Expenses - sample standard deviation",
  "Medical Expenses - coefficient of variation",
  "Medical Expenses - mean absolute deviation",
  "Medical Expenses - Q1",
  "Medical Expenses - median",
  "Medical Expenses - Q3",
  "Medical Expenses - IQR",

  # Income
  "Income - Min",
  "Income - Max",
  "Income - Sample Mean",
  "Income - Sample Variance",
  "Income - sample standard deviation",
  "Income - coefficient of variation",
  "Income - mean absolute deviation",
  "Income - Q1",
  "Income - median",
  "Income - Q3",
  "Income - IQR",

  # Education
  "Education - Min",
  "Education - Max",
  "Education - Sample Mean",
```

```
  "Education - Sample Variance",
  "Education - sample standard deviation",
  "Education - coefficient of variation",
  "Education - mean absolute deviation",
  "Education - Q1",
  "Education - median",
  "Education - Q3",
  "Education - IQR"
)

colnames(data2_summary) <- c("Values")

data2_summary

write.csv(data2_summary, "exports/data2_summary.csv", row.names = TRUE)

# 2B
# Outliers not in the range [Q1 - 1.5 * IQR, Q3 + 1.5 * IQR]

IQR_med = quantile(data2$medicalexpn, 0.75) - quantile(data2$medicalexpn,
0.25)
IQR_med

# get the lower and higher bound
low_med = quantile(data2$medicalexpn, 0.25) - 1.5 * IQR_med
high_med = quantile(data2$medicalexpn, 0.75) + 1.5 * IQR_med

# identify the outliers

# Outlier value(s)
data2$medicalexpn[
  which(data2$medicalexpn < low_med | data2$medicalexpn > high_med)
]

# Outlier Record(s) (Observations(s))
row.names(data2)[
  which(data2$medicalexpn < low_med | data2$medicalexpn > high_med)
]
# => The outlier is the Value 62.231 of row 27

# 2C
aggregated_medicalexpn = aggregate(
  data2$medicalexpn,
  list(
    Country = data2$country,
    Location = data2$location
  ),
  FUN = function(x) c(
    "Sample Mean" = mean(x),
    "Sample SD" = sd(x)
  )
)
```

```
write.csv(
  aggregated_medicalexpn,
  "exports/aggregated_data2_medicalexpn.csv",
  row.names = TRUE
)

# Bar Chart Draw
# Sample Mean Chart
barplot(
  x[,"Sample Mean"] ~ Country + Location,
  data = aggregated_medicalexpn,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Average Medical Expenses by Country and Location",
  ylab = "Average Medical Expenses",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
)

# Standard Deviation Chart
barplot(
  x[,"Sample SD"] ~ Country + Location,
  data = aggregated_medicalexpn,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Standard Deviation of Medical Expenses by Country and Location",
  ylab = "Standard Deviation of Medical Expenses",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
)


aggregated_income = aggregate(
  data2$income,
  list(
    Country = data2$country,
    Location = data2$location
  ),
  FUN = function(x) c(
```

```
    "Sample Mean" = mean(x),
    "Sample SD" = sd(x)
  )
)

write.csv(
  aggregated_income,
  "exports/aggregated_data2_income.csv",
  row.names = TRUE
)

# Bar Chart Draw
# Sample Mean Chart
barplot(
  x[,"Sample Mean"] ~ Country + Location,
  data = aggregated_income,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Average Income by Country and Location",
  ylab = "Average Income",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
)

# Standard Deviation Chart
barplot(
  x[,"Sample SD"] ~ Country + Location,
  data = aggregated_income,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Standard Deviation of Income by Country and Location",
  ylab = "Standard Deviation of Income",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
)


aggregated_education = aggregate(
  data2$education,
```

```
  list(
    Country = data2$country,
    Location = data2$location
  ),
  FUN = function(x) c(
    "Sample Mean" = mean(x),
    "Sample SD" = sd(x)
  )
)

write.csv(
  aggregated_education,
  "exports/aggregated_data2_education.csv",
  row.names = TRUE
)

# Bar Chart Draw
# Sample Mean Chart
barplot(
  x[,"Sample Mean"] ~ Country + Location,
  data = aggregated_education,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Average Education by Country and Location",
  ylab = "Average Education",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
)

# Standard Deviation Chart
barplot(
  x[,"Sample SD"] ~ Country + Location,
  data = aggregated_education,
  beside = T,
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1"),
  main = "Standard Deviation of Education by Country and Location",
  ylab = "Standard Deviation of Education",
  xlab = "Location"
)

legend(
  "topleft",
  c("Canada", "Mexico", "USA"),
  pch = 15,
  bty = "n",
  col = c("dodgerblue2", "firebrick2", "darkgoldenrod1")
```

```
)


# 2E - Draw a scatter plot of medical expenses (on y-axis) and income (on
x-axis).

plot(medicalexpn ~ income, data = data2)

plot(
  data2$income,
  data2$medicalexpn,
  xlab = "Income",
  ylab = "Medical Expenses"
)

# 2F - Calculate sample correlations between all numeric variables and
present them in a table.

correlation = cor(data2[,c(3, 4, 5)])

correlation

write.csv(
  correlation,
  "exports/data2_correlation.csv",
  row.names = TRUE
)
```