# An Investigation of Factors Influencing Emergency Healthcare Expenditures

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## Abstract

## Nature of the Data

The data includes summary of both male and female spending as "both", so in order to perform an analysis on this data, we decided to exclude the both data points to avoid double counting? It is important to acknowledge that this data only included those who identified as either male or female, so this is not a complete representationof the population.
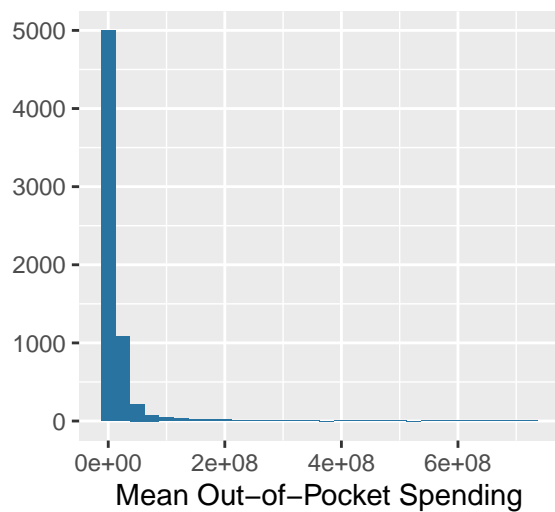
Normal Distribution of Mean Public Spending
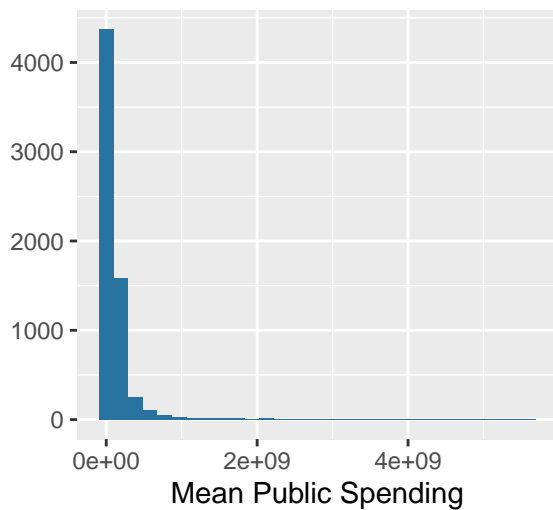
## Normal Distribution of Mean Priv



Mean Private Spending

## Normal Distribution of Mean Out
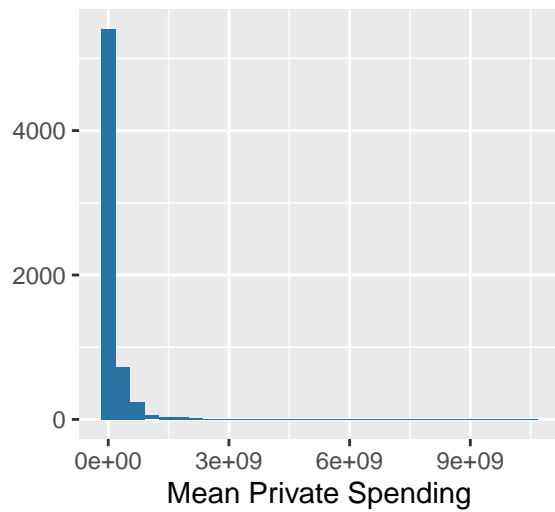


Mean Out-of-Pocket Spending

The normal distribution for public spending, private spending, and out-of-pocket pending all show a severe right skew in the data. Therefore, all three variables do not meet the normal distribution assumption needed for many tests, such as ANOVA; however, this can easily be resolved by applying a log transformation to the data to give a fairly normal distribution of the data.

## Log Normal Distribution of Mean



Log Mean Public Spending

## Log Normal Distribution of Mean



Log Mean Private Spending

Log Normal Distribution of Mean

Log Mean Out–of–Pocket Spending
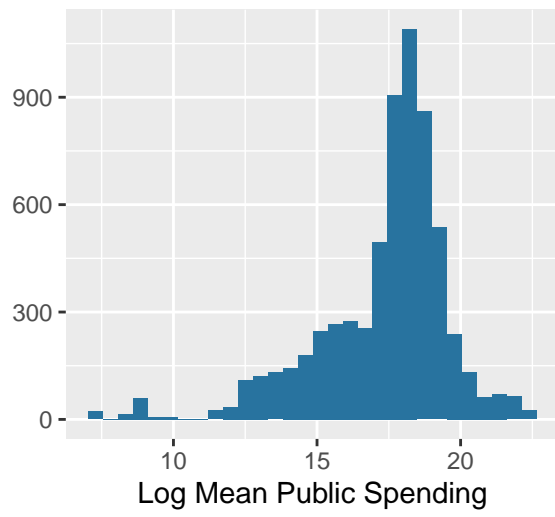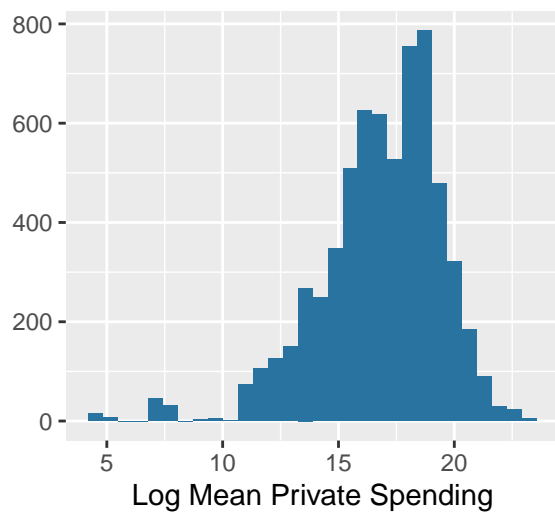
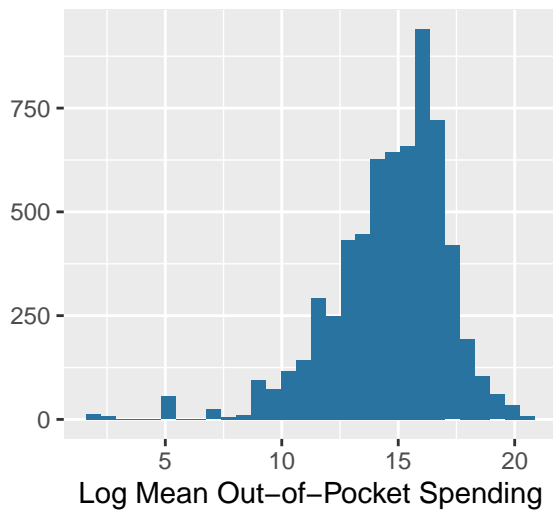These graphs of the log distribution of the various spending means appear to be fairly normal in distribution, which means they meet the requirements to be used in various analyses. In order to convert to log scale, those with mean_all, mean_pub, mean_pri, and mean_oop equal to zero must be excluded.

## Gender

Our first question in this analysis is if males and females spend a different amount of money on emergency services.

First this t-test looks at overall differences in log mean emergency department spending between males and females

```
##
##  Welch Two Sample t-test
##
## data:  spending_malefemale$lmean_all by spending_malefemale$sex
## t = 1.4247, df = 6219.5, p-value = 0.1543
## alternative hypothesis: true difference in means between group Female and group Male is
## 95 percent confidence interval:
##  -0.0315862  0.1996079
## sample estimates:
## mean in group Female   mean in group Male
##            18.06275              17.97874
```

This t-test shows that for mean spending of all emergency services payment types, the p value of 0.1543 (95% CI -0.0315862, 0.1996079) indicates there is not a significant difference between male and female spending.

Next, we perform a t-test on each type of insurance to see if there is a difference in spending between males and females:

```
##
##  Welch Two Sample t-test
##
## data:  spending_malefemale$lmean_pub by spending_malefemale$sex
## t = 1.8142, df = 6201, p-value = 0.0697
## alternative hypothesis: true difference in means between group Female and group Male is
## 95 percent confidence interval:
##  -0.00833746  0.21532602
## sample estimates:
## mean in group Female   mean in group Male
##            17.40512              17.30162
```

The t-test on emergency services spending for people who have public insurance indicates there is not a significant difference between male and female spending, with p value of 0.0697 (95% CI -0.00833746, 0.21532602).

```
##
##  Welch Two Sample t-test
##
## data:  spending_malefemale$lmean_pri by spending_malefemale$sex
## t = 0.70583, df = 6254.9, p-value = 0.4803
## alternative hypothesis: true difference in means between group Female and group Male is
## 95 percent confidence interval:
##  -0.08283085  0.17603825
## sample estimates:
## mean in group Female   mean in group Male
##            16.82891             16.78231
```

The t-test on emergency services spending for people who have private insurance indicates there is not a significant difference between male and female spending, with p value of 0.4803 (95% CI -0.08283085, 0.17603825).

```
##
##  Welch Two Sample t-test
##
## data:  spending_malefemale$lmean_oop by spending_malefemale$sex
## t = 0.9799, df = 6230.6, p-value = 0.3272
## alternative hypothesis: true difference in means between group Female and group Male is
## 95 percent confidence interval:
##  -0.0615859  0.1846904
## sample estimates:
## mean in group Female   mean in group Male
##            14.66032             14.59877
```

The t-test on emergency services spending for people who pay out of pocket indicates there is not a significant difference between male and female spending, with p value of 0.3272 (95% CI -0.0615859, 0.1846904).

The t-tests for each type of insurance indicate that there is not enough evidence to reject the null hypothesis that emergency department spending is the same for males and females who have public insurance, private insurance, or pay out of pocket, leading us to the conclusion that gender does not influence emergency spending in the forms of payment studied here.

### Disease category and Emergency Spending

In order to determine emergency department spending based on disease type, an ANOVA test is performed due to the data for spending on the log scale being normally distributed, relatively similar variance, and independent.

The null hypothesis for this ANOVA test is that the overall mean of spending are the same for each disease category

```
##               Df Sum Sq Mean Sq F value Pr(>F)
## agg_cause     14  19152  1368.0   521.9 <2e-16 ***
## Residuals   6365  16685     2.6
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Based on the p-value here of <2e-16, these data or more extreme data it is highly unlikely the null hypothesis is true. Therefore, we perform step-down tests using a Holm correction for multiple comparisons.

```
## [1] 92
```

The step-down t tests indicate 92 disease category pairs are different out of 105, indicating most disease categories do differ in the amount of government spending by the emergency department. There is lots of variation!!

```
## # A tibble: 15 x 5
##    term                                estimate std.error statistic  p.value
##    <chr>                                  <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                            17.7    0.0772    229.    0
##  2 agg_causeCancers                       -2.52   0.109     -23.1   2.71e-113
##  3 agg_causeCardiovascular diseases        1.29   0.109      11.8   7.26e- 32
##  4 agg_causeChronic respiratory diseases   1.40   0.111      12.7   1.65e- 36
##  5 agg_causeCommunicable and nutrition d~   1.73   0.109      15.9   1.05e- 55
##  6 agg_causeDiabetes and kidney diseases  -0.110  0.109      -1.01  3.13e-  1
##  7 agg_causeDigestive diseases             1.96   0.109      18.0   1.85e- 70
##  8 agg_causeEndocrine disorders           -1.15   0.109     -10.5   1.32e- 25
##  9 agg_causeInjuries                       2.68   0.109      24.5   3.15e-127
## 10 agg_causeMaternal and neonatal condit~ -3.12   0.130     -24.1   1.14e-122
## 11 agg_causeMusculoskeletal conditions     1.05   0.109       9.62  9.27e- 22
## 12 agg_causeNeurological disorders         0.970  0.109       8.88  8.41e- 19
## 13 agg_causeOther non-communicable disea~  1.60   0.109      14.6   1.33e- 47
## 14 agg_causePrevention and coordination   -3.00   0.109     -27.5   1.30e-157
## 15 agg_causeSkin and other sense organ d~  1.09   0.109       9.98  2.71e- 23
```

`glance(meanalldiseasecatfit)$r.squared`

```
## [1] 0.5344174
```
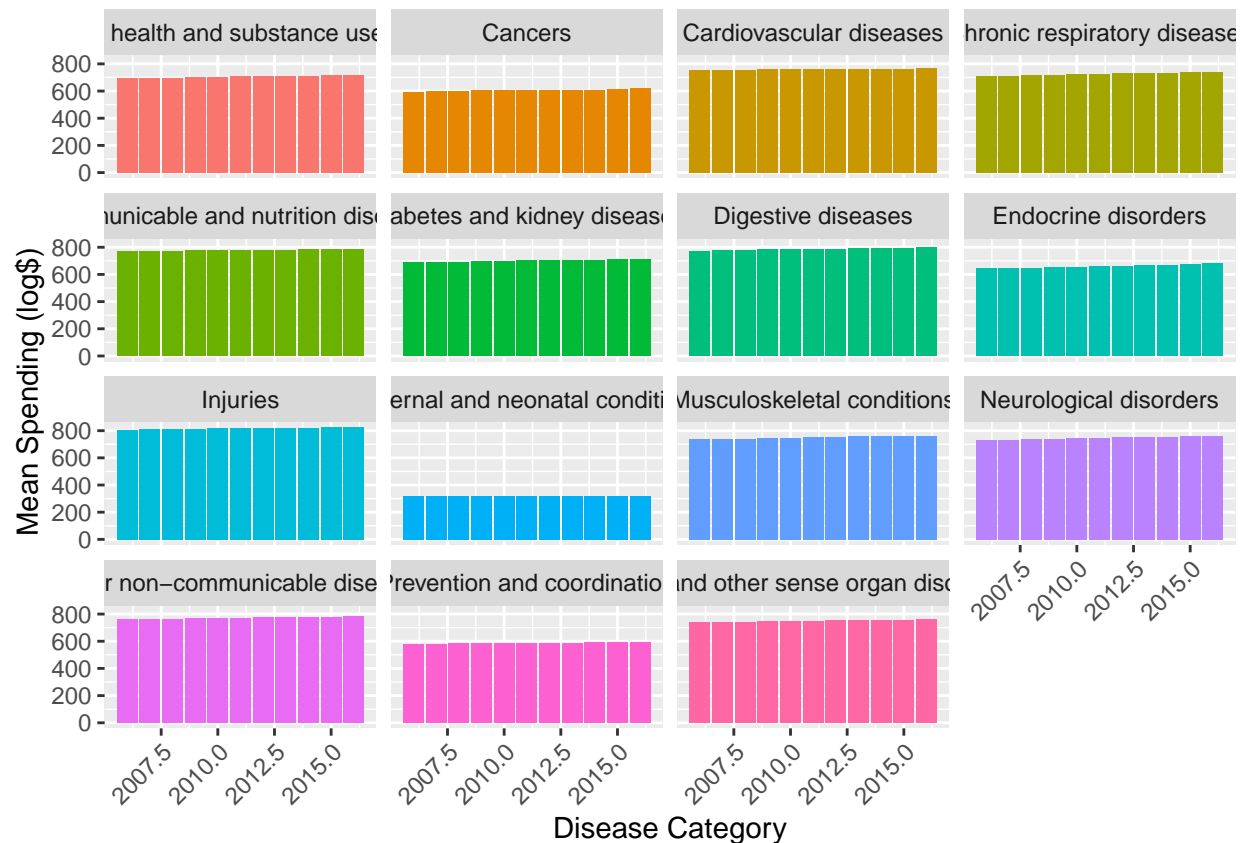


```
## # A tibble: 30 x 5
##    term                                estimate std.error statistic  p.value
##    <chr>                                  <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                            17.4    0.257      67.7   0
```

```
##  2 as.factor(year_id)2016                      0.546       0.363    1.50  1.33e- 1
##  3 agg_causeCancers                           -2.53        0.363   -6.98  4.94e-12
##  4 agg_causeCardiovascular diseases            1.39        0.363    3.84  1.32e- 4
##  5 agg_causeChronic respiratory diseases       1.38        0.368    3.75  1.88e- 4
##  6 agg_causeCommunicable and nutrition di~     1.77        0.363    4.87  1.30e- 6
##  7 agg_causeDiabetes and kidney diseases      -0.0974      0.363   -0.268 7.88e- 1
##  8 agg_causeDigestive diseases                 1.94        0.363    5.36  1.03e- 7
##  9 agg_causeEndocrine disorders               -1.28        0.363   -3.53  4.28e- 4
## 10 agg_causeInjuries                           2.75        0.363    7.58  7.22e-14
## # ... with 20 more rows
```

```
glance(spendingovertime_fit)$adj.r.squared
```

```
## [1] 0.5312989
```

### Age

!! had to take out the observations with "All Ages" because I think it will just mess up the pairs but let me know what you think or whether you think there's anything we can do with that group

We wonder whether there is a correlation between government healthcare expenditures in the emergency department and age. The age variable is categorical, split into 19 groups that generally include 5 years each, apart from the first (<1 year) and last (85 plus) groups.

To address this question, we began by using an overall test with ANOVA.

Below is an overall test of the null hypothesis that all of the means for age groups across the years are equal, as opposed to the alternative that at least one mean is different.

```
##                  Df Sum Sq Mean Sq F value Pr(>F)
## age_group_name   18   4239  235.50   52.17 <2e-16 ***
## Residuals      6031  27226    4.51
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

In this F-test (ndf = 18, ddf = 6229), a significant difference among age groups was identified. Our p-value tells us that this data (or data more extreme) would be very unlikely if the null hypothesis were true because it shows statistical significance at an alpha well below 0.05. Therefore, we reject the null hypothesis that the mean expenditures for all age groups are equal.

To see which specific means may be different from one another, we used planned step-down tests with a Holm correction to minimize Type I errors.

```
## [1] 99
```

The pairwise t-tests used for our ANOVA step-down tests suggest that there are 99 different age pairs out of the 171 possible combinations. This tells us that more age pairs are different than are similar and that therefore the majority of age group pairs differ in terms of mean expenditures.

```
agefit <- linear_reg() %>%
  set_engine("lm") %>%
  fit(lmean_all ~ age_group_name, data = spending_malefemale)
  tidy(agefit)
```

```
## # A tibble: 20 x 5
##    term                  estimate std.error statistic   p.value
##    <chr>                    <dbl>     <dbl>     <dbl>     <dbl>
##  1 (Intercept)              15.4      0.120    128.    0
##  2 age_group_name1 to 4      1.20     0.168      7.13 1.13e- 12
##  3 age_group_name10 to 14    1.92     0.168     11.5  3.74e- 30
```

```
##  4 age_group_name15 to 19       2.59     0.168      15.4    1.04e- 52
##  5 age_group_name20 to 24       2.96     0.168      17.7    3.38e- 68
##  6 age_group_name25 to 29       3.09     0.168      18.4    5.11e- 74
##  7 age_group_name30 to 34       3.16     0.168      18.8    7.10e- 77
##  8 age_group_name35 to 39       3.23     0.168      19.2    2.76e- 80
##  9 age_group_name40 to 44       3.30     0.168      19.7    1.34e- 83
## 10 age_group_name45 to 49       3.32     0.168      19.8    9.53e- 85
## 11 age_group_name5 to 9         1.27     0.168       7.58   4.07e- 14
## 12 age_group_name50 to 54       3.27     0.168      19.5    4.33e- 82
## 13 age_group_name55 to 59       2.89     0.168      17.2    5.13e- 65
## 14 age_group_name60 to 64       2.70     0.168      16.1    5.96e- 57
## 15 age_group_name65 to 69       2.63     0.168      15.7    1.90e- 54
## 16 age_group_name70 to 74       2.48     0.168      14.8    1.01e- 48
## 17 age_group_name75 to 79       2.37     0.168      14.1    1.58e- 44
## 18 age_group_name80 to 84       2.32     0.168      13.8    7.53e- 43
## 19 age_group_name85 plus        2.39     0.168      14.2    3.11e- 45
## 20 age_group_nameAll Ages       5.84     0.166      35.1    5.41e-247
```
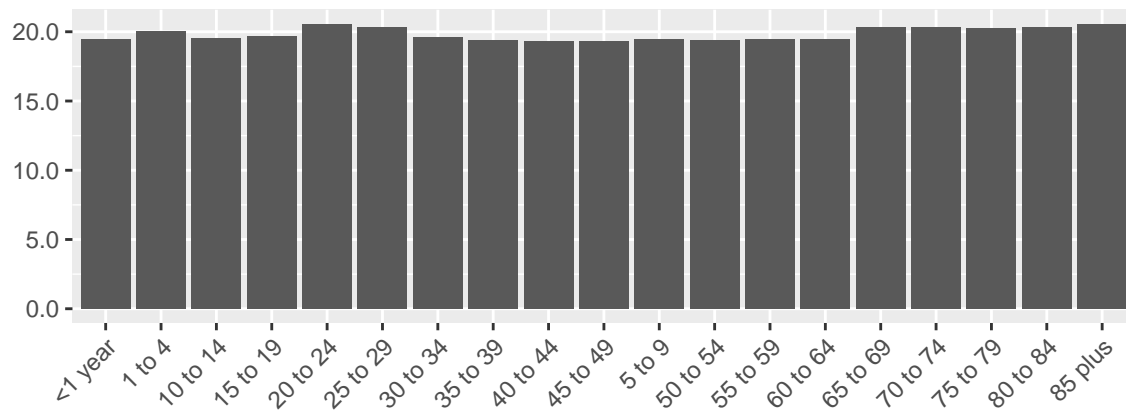
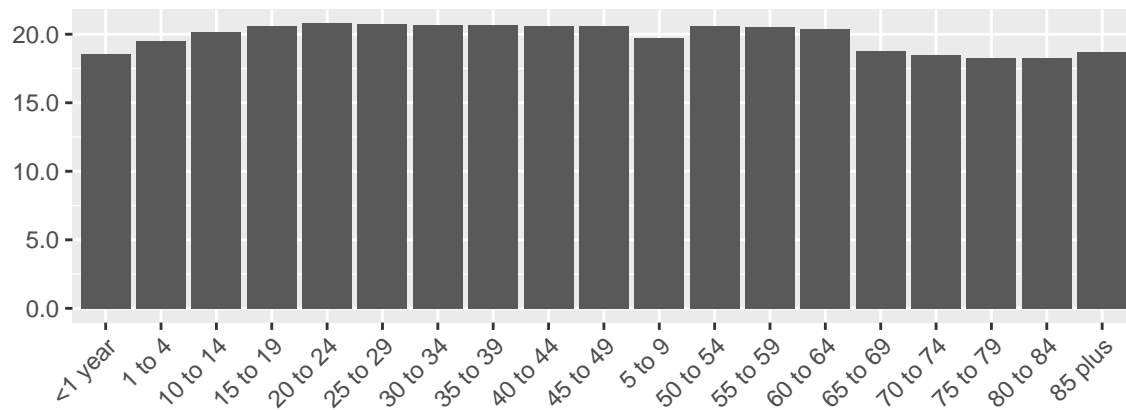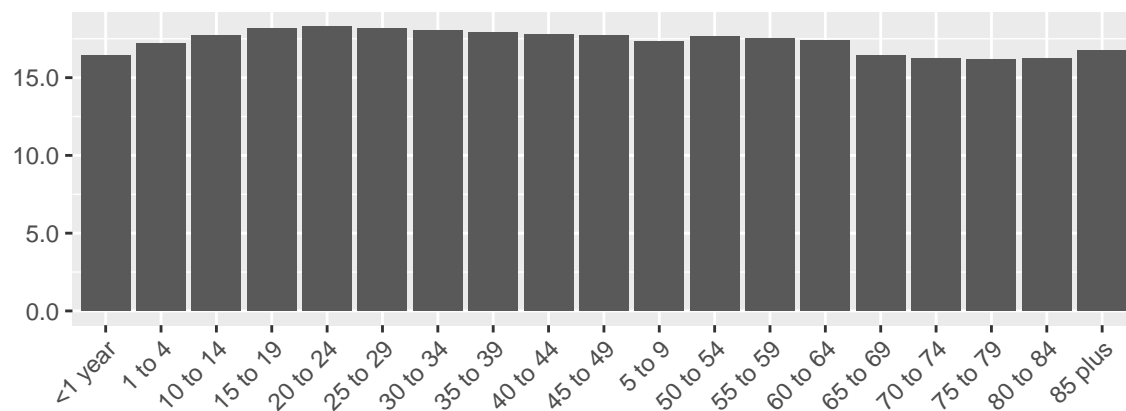## Emergency Department General Expenditures
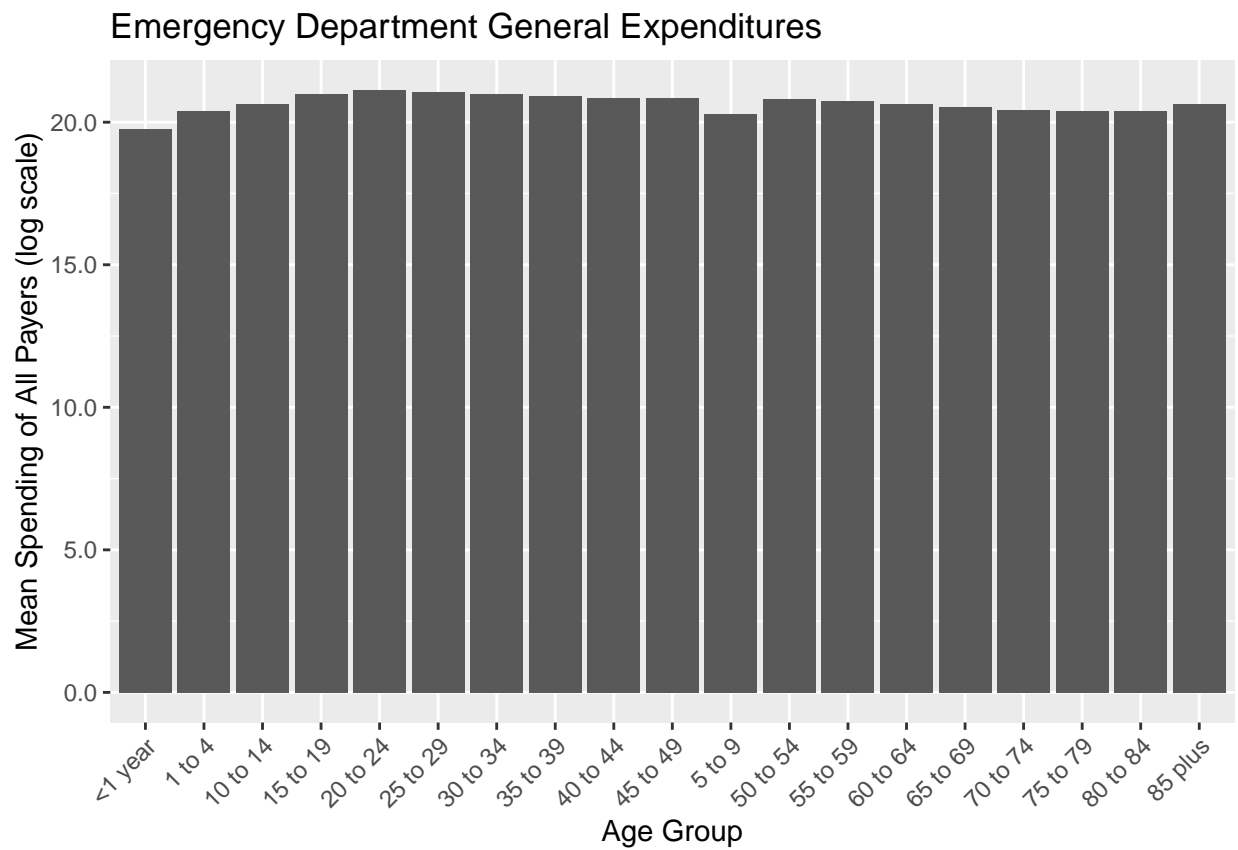
## Public Insurance Expenditures



## Private Insurance Expenditures



## Out of Pocket Expenditures



**Gender and Age Interaction**

```
## # A tibble: 3 x 5
##   term         estimate std.error statistic  p.value
##   <chr>           <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)  17.3       0.0445     390.    0
```

```
## 2 sexMale      -0.104    0.0574      -1.80 0.0712
## 3 age_group_id  0.00328  0.000887     3.70 0.000216

## [1] 0.002338971

## # A tibble: 4 x 5
##   term               estimate std.error statistic p.value
##   <chr>                 <dbl>     <dbl>     <dbl>   <dbl>
## 1 (Intercept)          17.3      0.0483    359.     0
## 2 sexMale              -0.0803   0.0694    -1.16    0.247
## 3 age_group_id          0.00379  0.00123    3.08    0.00211
## 4 sexMale:age_group_id -0.00106  0.00177   -0.595   0.552

## [1] 0.002237904

## # A tibble: 3 x 5
##   term         estimate std.error statistic  p.value
##   <chr>           <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)    17.1      0.0508    337.     0
## 2 sexMale        -0.0463   0.0656    -0.707  4.80e- 1
## 3 age_group_id   -0.0132   0.00101  -13.0    3.18e-38

## [1] 0.02563492

## # A tibble: 4 x 5
##   term               estimate std.error statistic  p.value
##   <chr>                 <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)          17.1      0.0552    310.     0
## 2 sexMale               0.00254  0.0793      0.0320 9.74e- 1
## 3 age_group_id         -0.0121   0.00141   -8.60    1.02e-17
## 4 sexMale:age_group_id -0.00222  0.00203   -1.10    2.73e- 1

## [1] 0.02566573

## # A tibble: 3 x 5
##   term         estimate std.error statistic  p.value
##   <chr>           <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)    14.9      0.0485    308.     0
## 2 sexMale        -0.0613   0.0626    -0.980  3.27e- 1
## 3 age_group_id   -0.0113   0.000967 -11.7    3.10e-31

## [1] 0.02080634

## # A tibble: 4 x 5
##   term               estimate std.error statistic  p.value
##   <chr>                 <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)          14.9      0.0526    283.     0
## 2 sexMale              -0.0181   0.0757    -0.239  8.11e- 1
## 3 age_group_id         -0.0103   0.00134   -7.70    1.59e-14
## 4 sexMale:age_group_id -0.00197  0.00193   -1.02    3.09e- 1

## [1] 0.02081155
```

In order to test the possibility that there is a joint interaction of gender and age, a main effects and interaction effects linear regression model has been fit to the data. As a whole, it shows that the interaction of gender and age slightly increases the accuracy of the regression for public and private spending as seen by the increased adjusted R^2 value. However, for out-of-pocket spending, it decreases the adjusted R^2 value. Nevertheless, overall, the adjusted R^2 values for all three types of spending are incredibly low, which further point to our conclusion that age may not affect the level of spending from different sources.

## Age and Disease Type Interaction

```
## # A tibble: 16 x 5
##    term                                estimate std.error statistic  p.value
##    <chr>                                  <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                          17.1     0.0780    219.     0
##  2 agg_causeCancers                     -2.68    0.109     -24.6    3.75e-128
##  3 agg_causeCardiovascular diseases      1.16    0.109      10.7    1.92e- 26
##  4 agg_causeChronic respiratory diseases 1.27    0.110      11.5    2.51e- 30
##  5 agg_causeCommunicable and nutrition d~ 1.59   0.109      14.6    1.68e- 47
##  6 agg_causeDiabetes and kidney diseases 0.0502  0.109       0.462  6.44e-  1
##  7 agg_causeDigestive diseases           1.64    0.109      15.1    1.30e- 50
##  8 agg_causeEndocrine disorders         -1.27    0.109     -11.7    2.94e- 31
##  9 agg_causeInjuries                     1.97    0.109      18.1    1.68e- 71
## 10 agg_causeMaternal and neonatal condit~ -3.14  0.129     -24.4    1.03e-125
## 11 agg_causeMusculoskeletal conditions   0.806   0.109       7.42   1.32e- 13
## 12 agg_causeNeurological disorders       0.760   0.109       7.00   2.77e- 12
## 13 agg_causeOther non-communicable disea~ 1.23   0.109      11.3    1.65e- 29
## 14 agg_causePrevention and coordination -3.06    0.109     -28.2    3.71e-165
## 15 agg_causeSkin and other sense organ d~ 0.863  0.109       7.95   2.22e- 15
## 16 age_group_id                          0.00334 0.000623    5.35   9.00e-  8
```

```
## [1] 0.506887
```

```
## # A tibble: 30 x 5
##    term                                estimate std.error statistic  p.value
##    <chr>                                  <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                          17.3     0.0907    191.     0
##  2 agg_causeCancers                     -3.14    0.128     -24.5    1.27e-126
##  3 agg_causeCardiovascular diseases      0.630   0.128       4.91   9.52e-  7
##  4 agg_causeChronic respiratory diseases 1.06    0.129       8.22   2.35e- 16
##  5 agg_causeCommunicable and nutrition d~ 1.42   0.128      11.0    4.05e- 28
##  6 agg_causeDiabetes and kidney diseases -0.244  0.128      -1.90   5.70e-  2
##  7 agg_causeDigestive diseases           1.48    0.128      11.6    1.19e- 30
##  8 agg_causeEndocrine disorders         -1.44    0.128     -11.2    6.78e- 29
##  9 agg_causeInjuries                     1.72    0.128      13.4    2.25e- 40
## 10 agg_causeMaternal and neonatal condit~ -2.34  0.154     -15.2    4.33e- 51
## # ... with 20 more rows
```

```
## [1] 0.529351
```

```
## # A tibble: 16 x 5
##    term                                estimate std.error statistic  p.value
##    <chr>                                  <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                          16.4     0.0903    182.     0
##  2 agg_causeCancers                     -2.24    0.126     -17.8    1.48e- 69
##  3 agg_causeCardiovascular diseases      1.62    0.126      12.9    1.75e- 37
##  4 agg_causeChronic respiratory diseases 1.71    0.127      13.4    1.13e- 40
##  5 agg_causeCommunicable and nutrition d~ 2.05   0.126      16.3    2.02e- 58
##  6 agg_causeDiabetes and kidney diseases -0.245  0.126      -1.94   5.19e-  2
##  7 agg_causeDigestive diseases           2.43    0.126      19.3    6.39e- 81
##  8 agg_causeEndocrine disorders         -0.793   0.126      -6.31   2.99e- 10
##  9 agg_causeInjuries                     3.44    0.126      27.3    9.02e-156
## 10 agg_causeMaternal and neonatal condit~ -3.16  0.149     -21.2    2.27e- 96
## 11 agg_causeMusculoskeletal conditions   1.50    0.126      11.9    2.36e- 32
## 12 agg_causeNeurological disorders       1.32    0.126      10.5    1.29e- 25
```

```
## 13 agg_causeOther non-communicable disea~    2.03    0.126        16.2  1.27e- 57
## 14 agg_causePrevention and coordination    -2.64    0.126       -21.0  2.18e- 94
## 15 agg_causeSkin and other sense organ d~   1.41    0.126        11.2  8.06e- 29
## 16 age_group_id                            -0.0131  0.000722     -18.2  4.45e- 72
## [1] 0.5054947

## # A tibble: 30 x 5
##    term                                   estimate std.error statistic  p.value
##    <chr>                                     <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                               16.7     0.106     157.    0
##  2 agg_causeCancers                         -2.77     0.151     -18.4  1.21e-73
##  3 agg_causeCardiovascular diseases          1.05     0.151       6.96 3.67e-12
##  4 agg_causeChronic respiratory diseases     1.50     0.152       9.90 6.18e-23
##  5 agg_causeCommunicable and nutrition di~   1.82     0.151      12.1  2.51e-33
##  6 agg_causeDiabetes and kidney diseases    -0.647    0.151      -4.30 1.74e- 5
##  7 agg_causeDigestive diseases               2.31     0.151      15.3  5.24e-52
##  8 agg_causeEndocrine disorders             -1.04     0.151      -6.94 4.46e-12
##  9 agg_causeInjuries                         3.23     0.151      21.4  1.91e-98
## 10 agg_causeMaternal and neonatal conditi~  -2.78     0.181     -15.4  2.21e-52
## # ... with 20 more rows

## [1] 0.5149051

## # A tibble: 16 x 5
##    term                                   estimate std.error statistic  p.value
##    <chr>                                     <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                               14.7    0.0850     173.    0
##  2 agg_causeCancers                         -2.75     0.118     -23.3  6.48e-115
##  3 agg_causeCardiovascular diseases          0.975    0.118       8.23 2.17e- 16
##  4 agg_causeChronic respiratory diseases     1.11     0.120       9.26 2.68e- 20
##  5 agg_causeCommunicable and nutrition d~    1.67     0.118      14.1  1.02e- 44
##  6 agg_causeDiabetes and kidney diseases    -0.428    0.118      -3.62 3.03e-  4
##  7 agg_causeDigestive diseases               1.83     0.118      15.5  5.56e- 53
##  8 agg_causeEndocrine disorders             -0.917    0.118      -7.75 1.08e- 14
##  9 agg_causeInjuries                         2.65     0.118      22.4  9.40e-107
## 10 agg_causeMaternal and neonatal condit~   -3.52     0.141     -25.1  1.97e-132
## 11 agg_causeMusculoskeletal conditions       0.888    0.118       7.51 6.94e- 14
## 12 agg_causeNeurological disorders           0.736    0.118       6.22 5.30e- 10
## 13 agg_causeOther non-communicable disea~    1.57     0.118      13.3  1.30e- 39
## 14 agg_causePrevention and coordination     -3.34     0.118     -28.2  1.73e-165
## 15 agg_causeSkin and other sense organ d~    0.841    0.118       7.10 1.37e- 12
## 16 age_group_id                             -0.0112   0.000680  -16.5  3.10e- 60

## [1] 0.5161683

## # A tibble: 30 x 5
##    term                                   estimate std.error statistic  p.value
##    <chr>                                     <dbl>     <dbl>     <dbl>    <dbl>
##  1 (Intercept)                               14.9     0.100     149.    0
##  2 agg_causeCancers                         -3.18     0.142     -22.4  2.10e-107
##  3 agg_causeCardiovascular diseases          0.404    0.142       2.85 4.34e-  3
##  4 agg_causeChronic respiratory diseases     0.893    0.143       6.26 4.13e- 10
##  5 agg_causeCommunicable and nutrition d~    1.50     0.142      10.6  5.92e- 26
##  6 agg_causeDiabetes and kidney diseases    -0.797    0.142      -5.63 1.91e-  8
##  7 agg_causeDigestive diseases               1.68     0.142      11.9  3.63e- 32
##  8 agg_causeEndocrine disorders             -1.14     0.142      -8.08 7.94e- 16
```

```
##  9 agg_causeInjuries                        2.39      0.142      16.9  1.79e- 62
## 10 agg_causeMaternal and neonatal condit~   -3.09      0.170     -18.2  7.93e- 72
## # ... with 20 more rows

## [1] 0.5261024
```