Analysis

2024-11-30

```
data <- read.csv("pandemic_data.csv")
head(data)
```

```
##    peak.inf soc.iso rate.vac quar.dur num.daily
## 1 0.8071379     0.0     0.00        0        15
## 2 0.6471836     0.5     0.00        0        15
## 3 0.2764590     1.0     0.00        0        15
## 4 0.8095392     0.0     0.01        0        15
## 5 0.7619943     0.5     0.01        0        15
## 6 0.1626645     1.0     0.01        0        15
```

```
summary(data) # peak.inf is i+q
```

```
##     peak.inf          soc.iso       rate.vac       quar.dur    num.daily
##  Min.   :0.01002   Min.   :0.0   Min.   :0.00   Min.   : 0   Min.   :15
##  1st Qu.:0.27646   1st Qu.:0.0   1st Qu.:0.00   1st Qu.: 0   1st Qu.:15
##  Median :0.72210   Median :0.5   Median :0.01   Median : 7   Median :30
##  Mean   :0.58065   Mean   :0.5   Mean   :0.01   Mean   : 7   Mean   :30
##  3rd Qu.:0.84296   3rd Qu.:1.0   3rd Qu.:0.02   3rd Qu.:14   3rd Qu.:45
##  Max.   :0.93448   Max.   :1.0   Max.   :0.02   Max.   :14   Max.   :45
```

```
# Anova
anova_model <- aov(peak.inf ~ soc.iso * rate.vac * quar.dur * num.daily, data = data)
summary(anova_model)
```

```
##                                    Df Sum Sq Mean Sq F value   Pr(>F)
## soc.iso                             1  4.897   4.897 189.338  < 2e-16 ***
## rate.vac                            1  0.010   0.010   0.374   0.5430
## quar.dur                            1  0.447   0.447  17.297 9.56e-05 ***
## num.daily                           1  0.888   0.888  34.330 1.69e-07 ***
## soc.iso:rate.vac                    1  0.000   0.000   0.017   0.8975
## soc.iso:quar.dur                    1  0.090   0.090   3.491   0.0662 .
## rate.vac:quar.dur                   1  0.000   0.000   0.001   0.9818
## soc.iso:num.daily                   1  0.029   0.029   1.127   0.2923
## rate.vac:num.daily                  1  0.019   0.019   0.735   0.3944
## quar.dur:num.daily                  1  0.001   0.001   0.027   0.8696
## soc.iso:rate.vac:quar.dur           1  0.009   0.009   0.333   0.5658
## soc.iso:rate.vac:num.daily          1  0.001   0.001   0.042   0.8387
## soc.iso:quar.dur:num.daily          1  0.080   0.080   3.107   0.0827 .
## rate.vac:quar.dur:num.daily         1  0.001   0.001   0.021   0.8860
## soc.iso:rate.vac:quar.dur:num.daily 1  0.014   0.014   0.540   0.4652
## Residuals                          65  1.681   0.026
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Regression and Box-Cox
lm_model <- lm(peak.inf ~ soc.iso * rate.vac * quar.dur * num.daily, data = data)
```

```r
summary(lm_model)
```

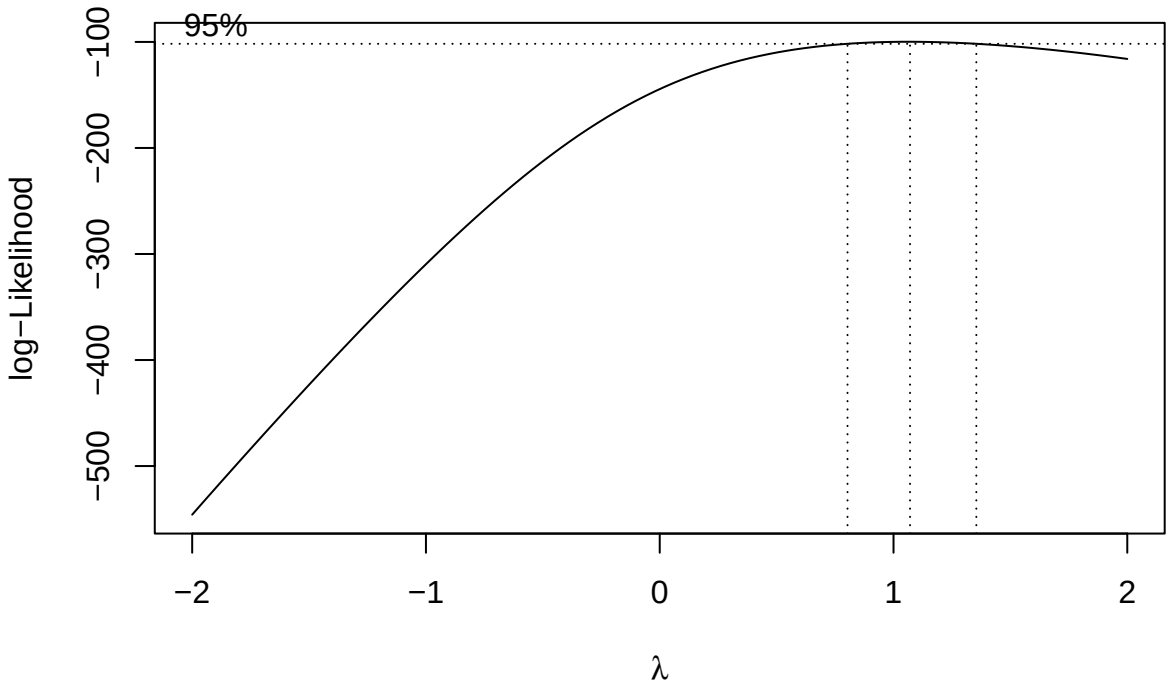
```
##
## Call:
## lm(formula = peak.inf ~ soc.iso * rate.vac * quar.dur * num.daily,
##     data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.39881 -0.08998 -0.03392  0.09016  0.32617
##
## Coefficients:
##                                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)                          7.914e-01  1.869e-01   4.235 7.35e-05 ***
## soc.iso                             -6.715e-01  2.895e-01  -2.319   0.0235 *
## rate.vac                             3.868e+00  1.448e+01   0.267   0.7901
## quar.dur                            -8.537e-03  2.068e-02  -0.413   0.6811
## num.daily                            4.287e-03  5.767e-03   0.743   0.4599
## soc.iso:rate.vac                    -1.759e+01  2.243e+01  -0.784   0.4356
## soc.iso:quar.dur                    -3.533e-03  3.204e-02  -0.110   0.9125
## rate.vac:quar.dur                   -1.258e+00  1.602e+00  -0.786   0.4350
## soc.iso:num.daily                    6.677e-03  8.934e-03   0.747   0.4575
## rate.vac:num.daily                  -1.199e-01  4.467e-01  -0.268   0.7892
## quar.dur:num.daily                   1.828e-04  6.382e-04   0.286   0.7755
## soc.iso:rate.vac:quar.dur            2.229e+00  2.481e+00   0.898   0.3724
## soc.iso:rate.vac:num.daily           4.832e-01  6.921e-01   0.698   0.4875
## soc.iso:quar.dur:num.daily          -5.396e-04  9.887e-04  -0.546   0.5870
## rate.vac:quar.dur:num.daily          3.263e-02  4.943e-02   0.660   0.5116
## soc.iso:rate.vac:quar.dur:num.daily -5.625e-02  7.658e-02  -0.735   0.4652
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1608 on 65 degrees of freedom
## Multiple R-squared:  0.7942, Adjusted R-squared:  0.7467
## F-statistic: 16.72 on 15 and 65 DF,  p-value: < 2.2e-16
```

```r
confint(lm_model, level = 0.95)
```

```
##                                          2.5 %       97.5 %
## (Intercept)                          0.418174816  1.164610401
## soc.iso                             -1.249655121 -0.093282085
## rate.vac                            -25.041273167 32.777378637
## quar.dur                             -0.049835522  0.032762552
## num.daily                            -0.007230679  0.015804824
## soc.iso:rate.vac                    -62.378235189 27.194035027
## soc.iso:quar.dur                     -0.067513048  0.060447338
## rate.vac:quar.dur                    -4.457253629  1.940765672
## soc.iso:num.daily                    -0.011165802  0.024520645
## rate.vac:num.daily                   -1.012059176  0.772263157
## quar.dur:num.daily                   -0.001091752  0.001457280
## soc.iso:rate.vac:quar.dur            -2.726966160  7.184802721
## soc.iso:rate.vac:num.daily           -0.898927600  1.865332672
## soc.iso:quar.dur:num.daily           -0.002514115  0.001434828
## rate.vac:quar.dur:num.daily          -0.066097189  0.131349973
```

```
## soc.iso:rate.vac:quar.dur:num.daily  -0.209194848  0.096688980
```

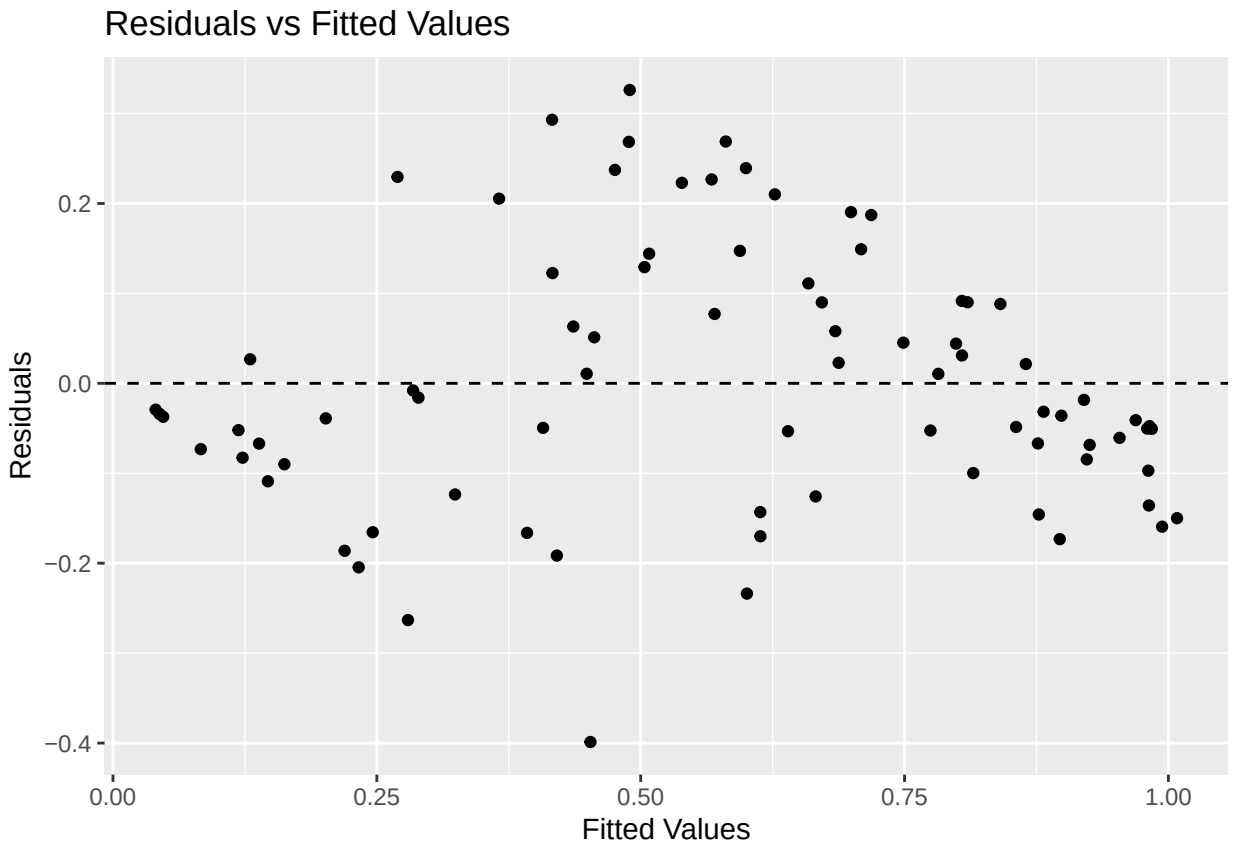
```
# Box-Cox Transformation
boxcox_result <- boxcox(lm_model, lambda = seq(-2, 2, by = 0.1))
```



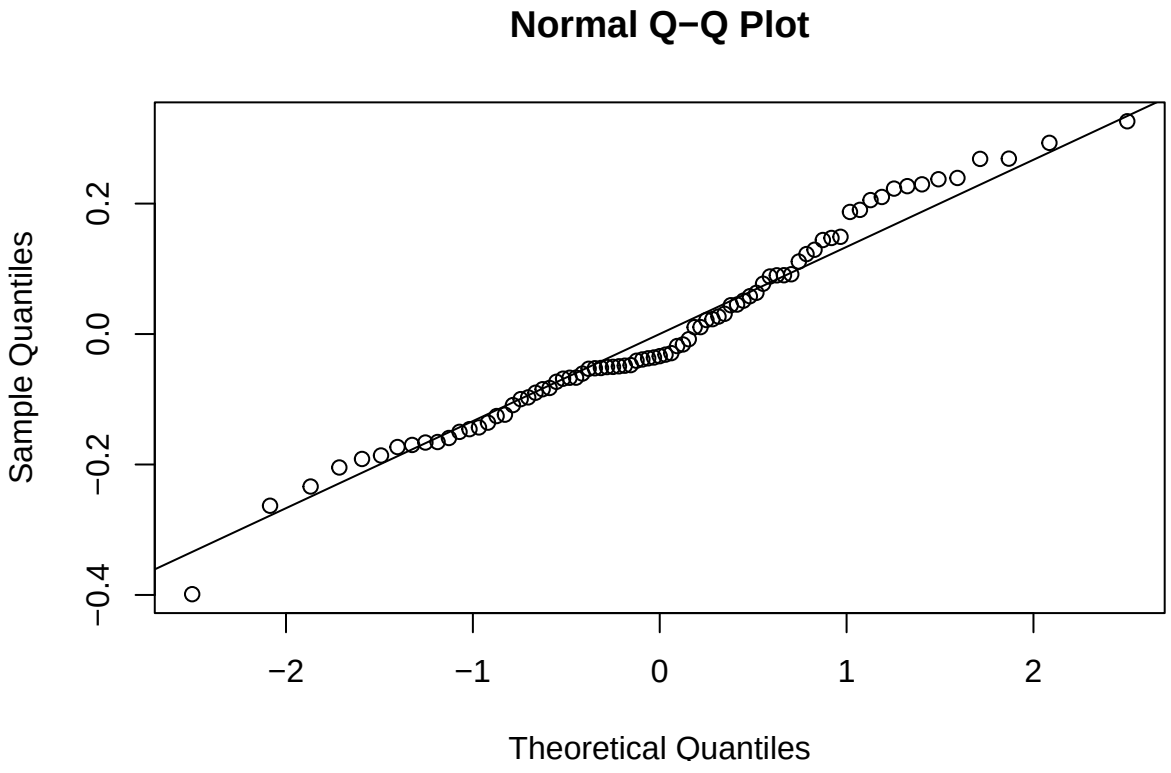

```
optimal_lambda <- boxcox_result$x[which.max(boxcox_result$y)]
optimal_lambda # no transformation
```

```
## [1] 1.070707
```

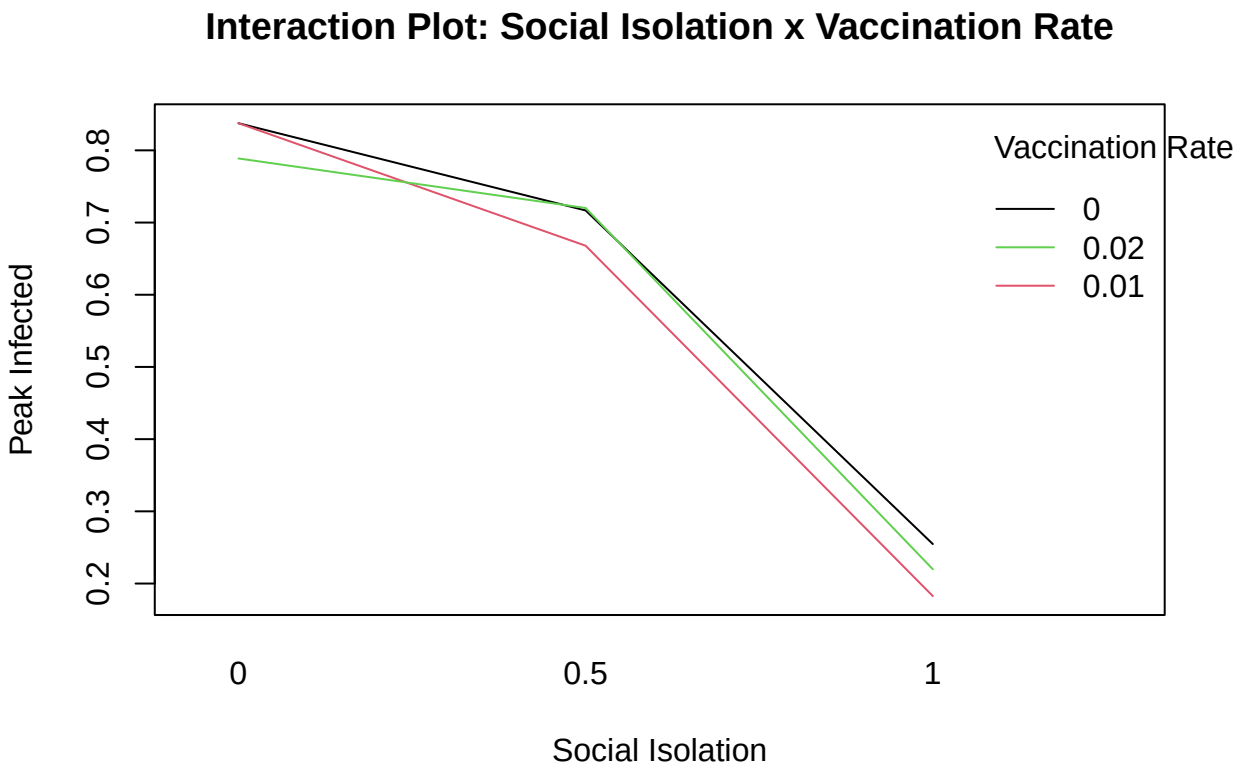
```
# Residual plots
residuals_plot <- ggplot(data.frame(fitted = lm_model$fitted.values,
                                    residuals = lm_model$residuals),
                         aes(x = fitted, y = residuals)) +
  geom_point() +
  geom_hline(yintercept = 0, linetype = "dashed") +
  labs(title = "Residuals vs Fitted Values", x = "Fitted Values", y = "Residuals")
print(residuals_plot)
```



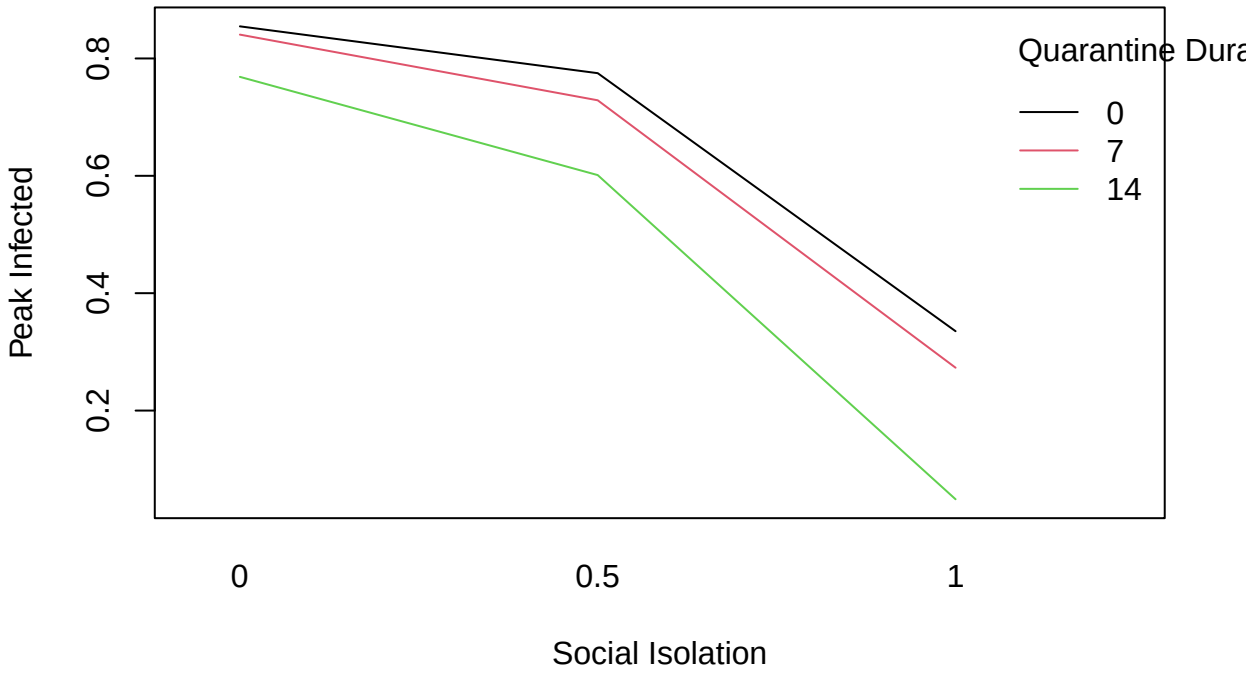

```r
# Q-Q Plot
qqnorm(lm_model$residuals, main = "Normal Q-Q Plot")
qqline(lm_model$residuals)
```



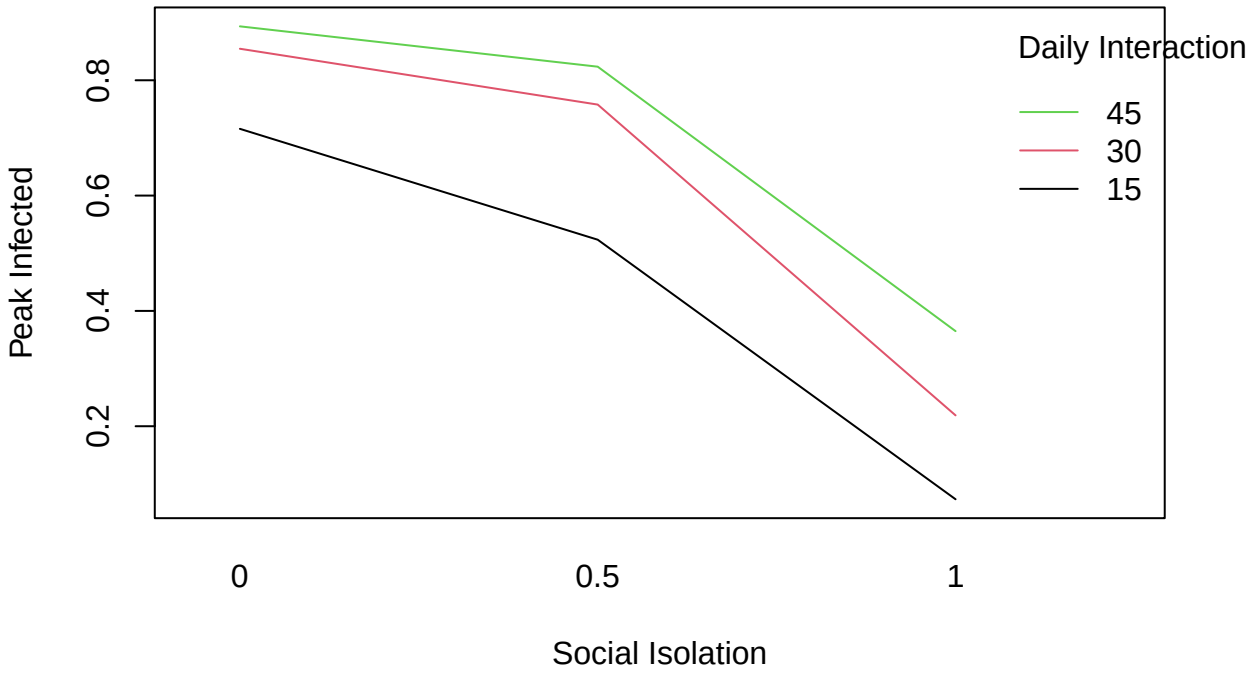
```r
# Graphics
# Interaction plots
interaction.plot(
  x.factor = data$soc.iso,
  trace.factor = data$rate.vac,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Social Isolation x Vaccination Rate",
  xlab = "Social Isolation",
  ylab = "Peak Infected",
  trace.label = "Vaccination Rate"
)
```



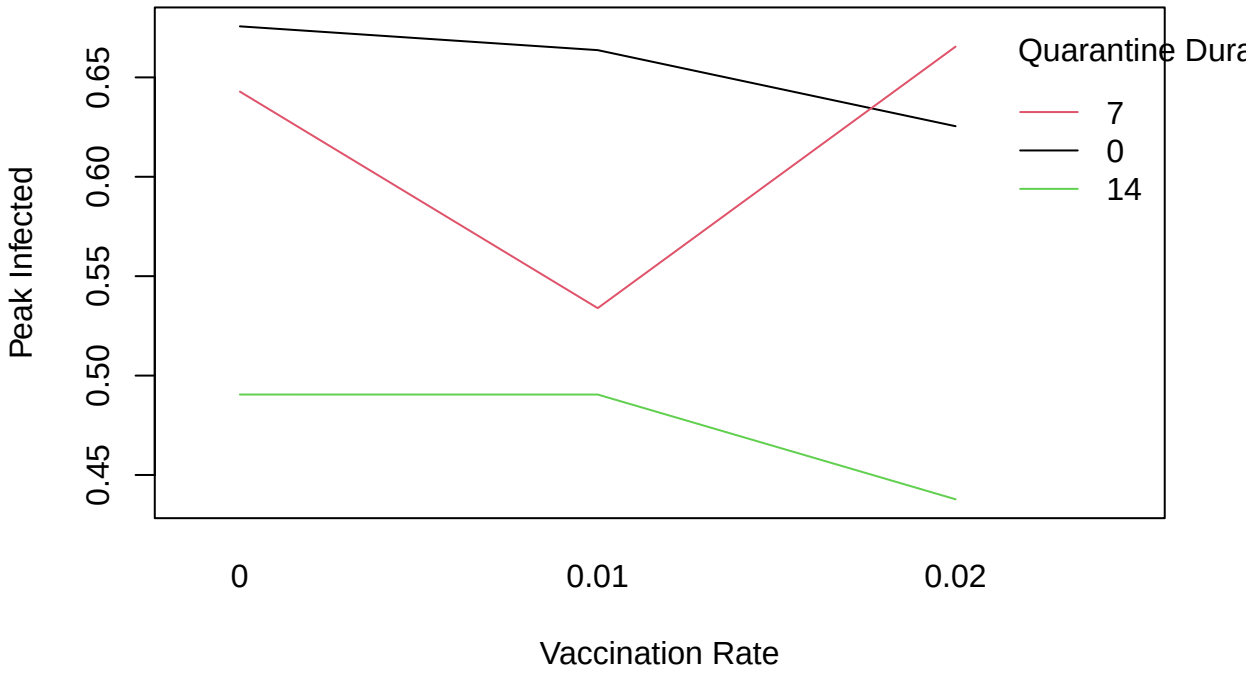

```r
interaction.plot(
  x.factor = data$soc.iso,
  trace.factor = data$quar.dur,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Social Isolation x Quarantine Duration",
  xlab = "Social Isolation",
  ylab = "Peak Infected",
  trace.label = "Quarantine Duration"
)
```



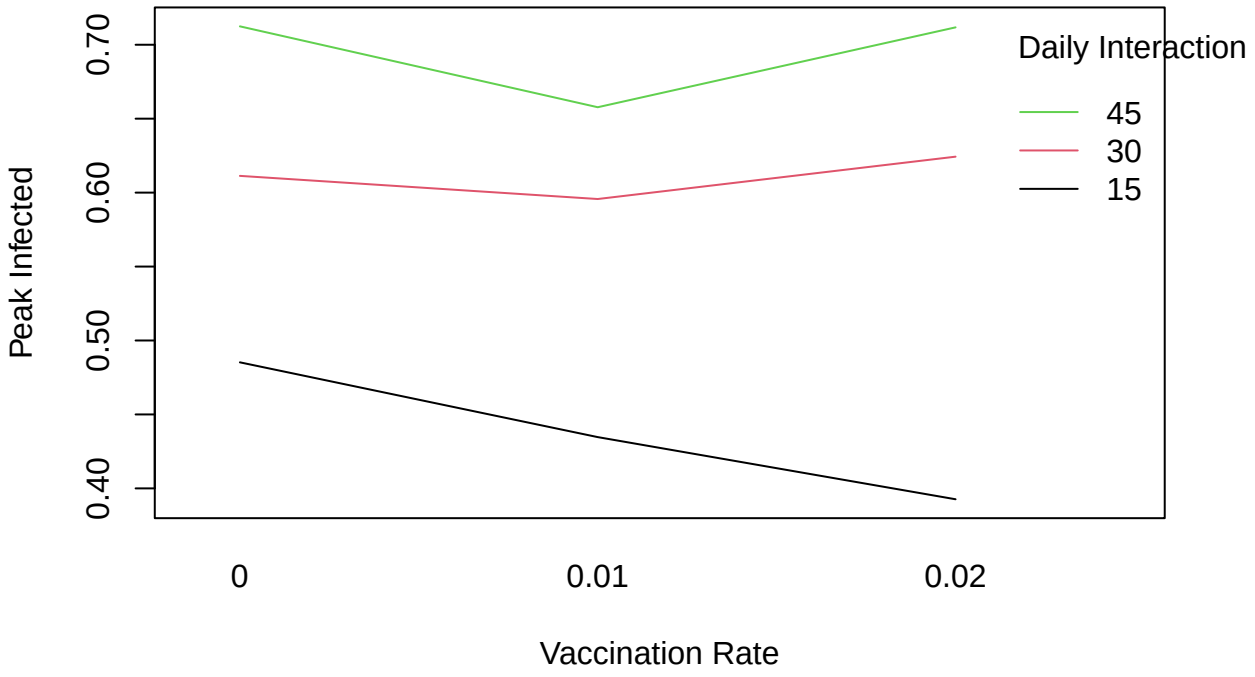

```
interaction.plot(
  x.factor = data$soc.iso,
  trace.factor = data$num.daily,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Social Isolation x Daily Interactions",
  xlab = "Social Isolation",
  ylab = "Peak Infected",
  trace.label = "Daily Interactions"
)
```



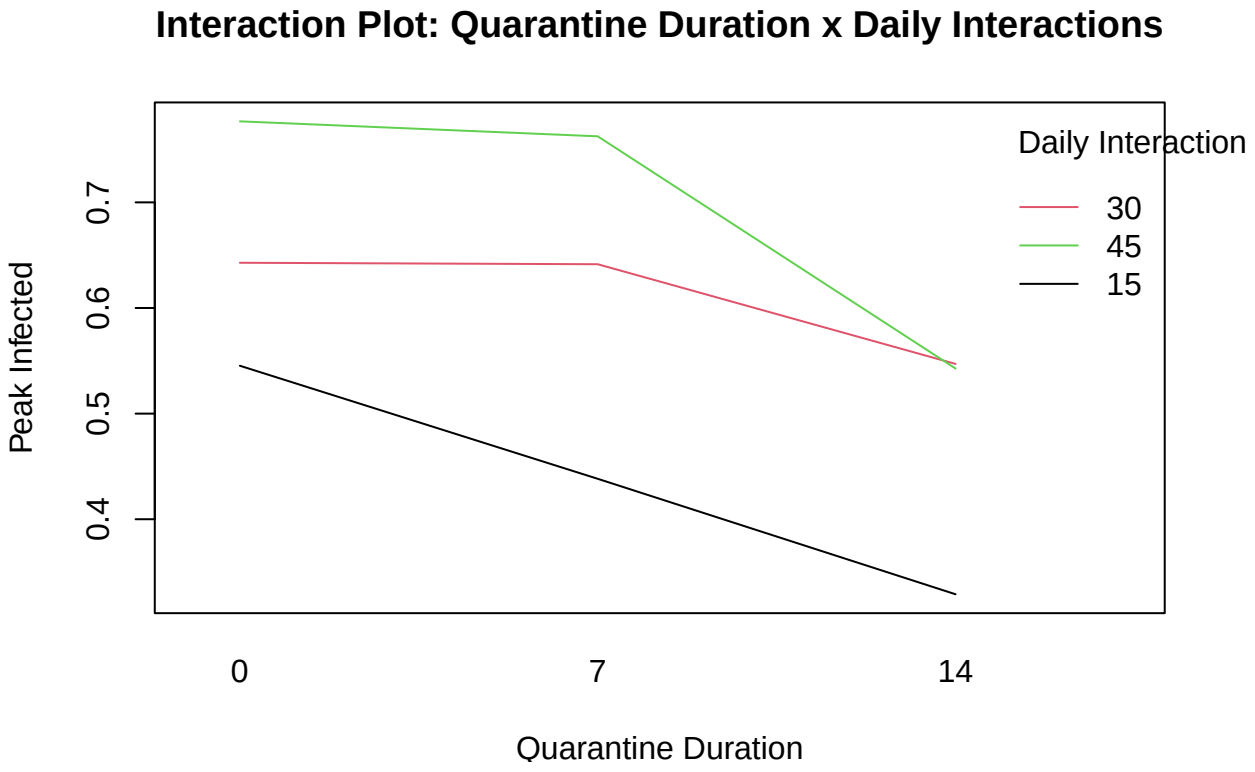

```
interaction.plot(
  x.factor = data$rate.vac,
  trace.factor = data$quar.dur,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Vaccination Rate x Quarantine Duration",
  xlab = "Vaccination Rate",
  ylab = "Peak Infected",
  trace.label = "Quarantine Duration"
)
```



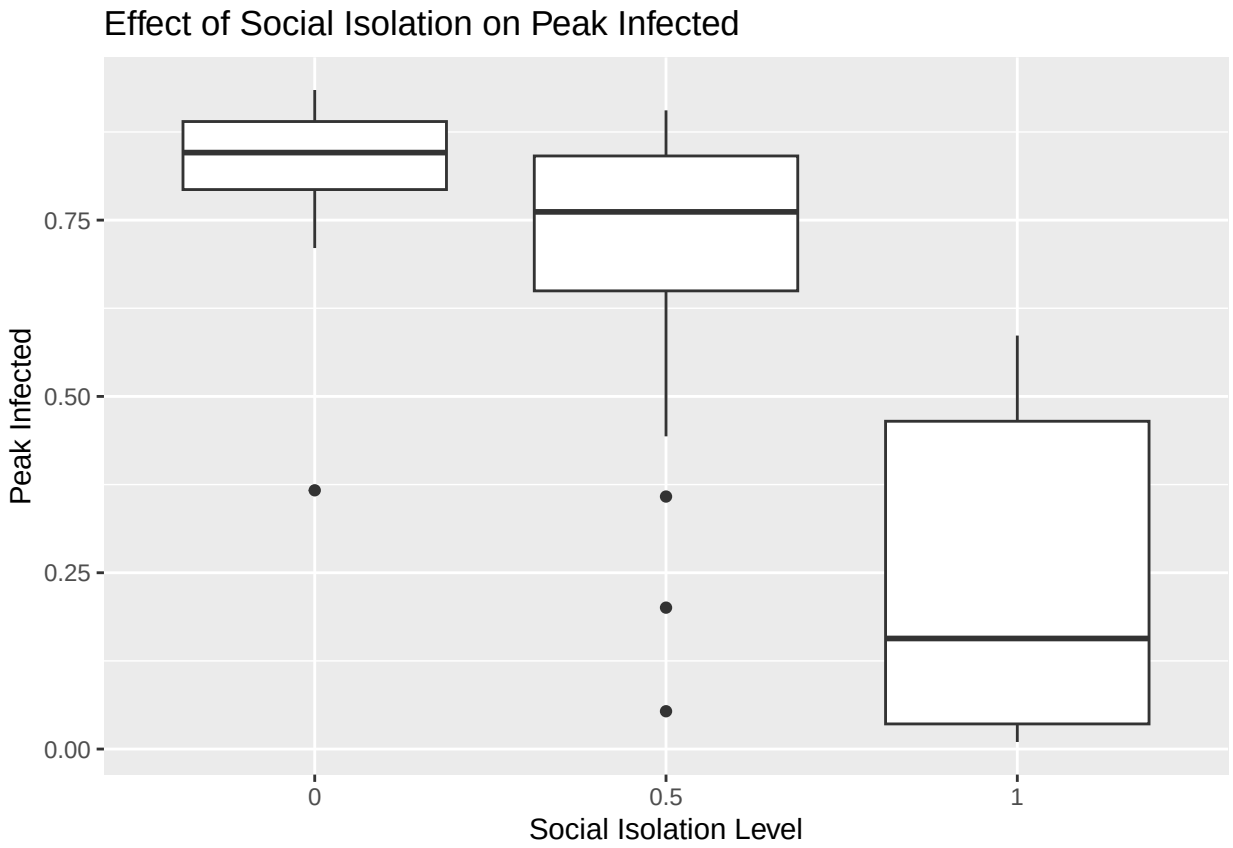

```
interaction.plot(
  x.factor = data$rate.vac,
  trace.factor = data$num.daily,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Vaccination Rate x Daily Interactions",
  xlab = "Vaccination Rate",
  ylab = "Peak Infected",
  trace.label = "Daily Interactions"
)
```



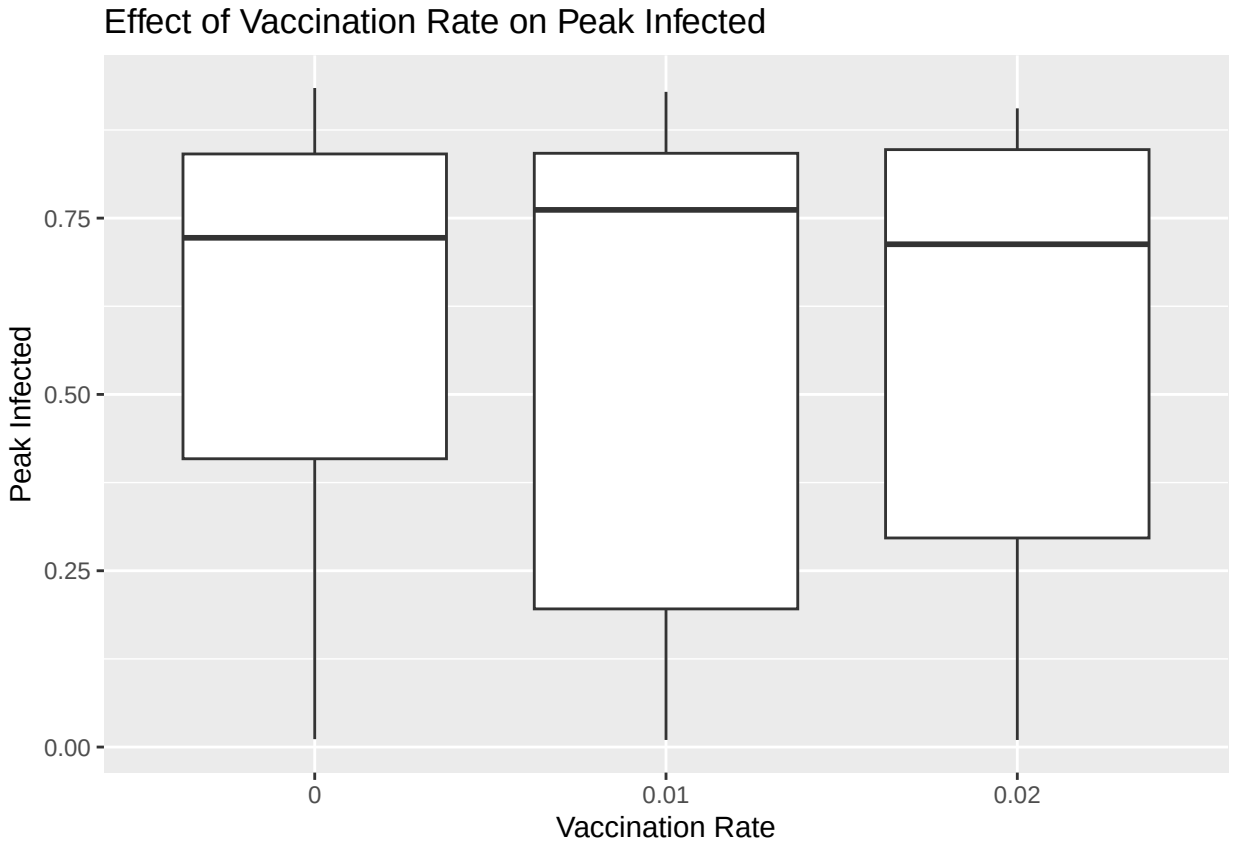

```r
interaction.plot(
  x.factor = data$quar.dur,
  trace.factor = data$num.daily,
  response = data$peak.inf,
  col = 1:4,
  lty = 1,
  main = "Interaction Plot: Quarantine Duration x Daily Interactions",
  xlab = "Quarantine Duration",
  ylab = "Peak Infected",
  trace.label = "Daily Interactions"
)
```



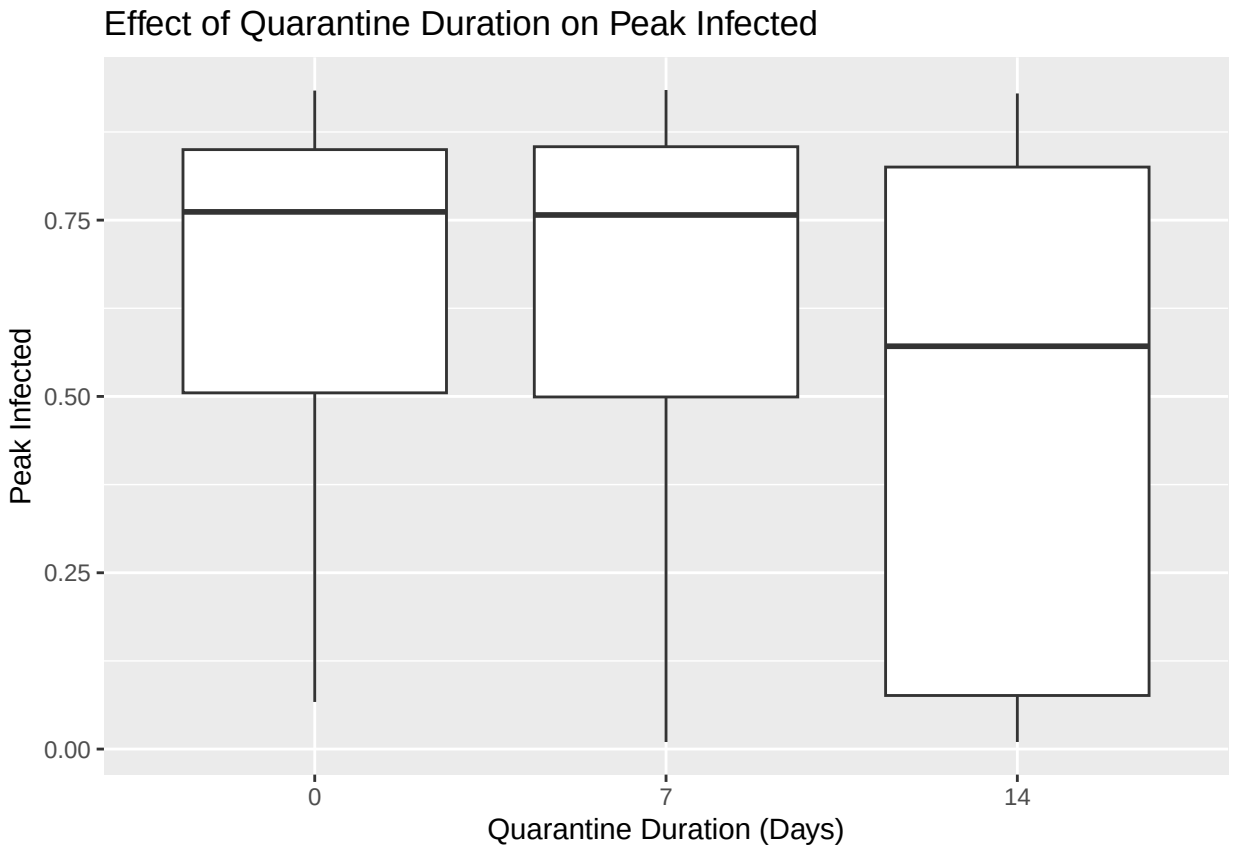

```r
# Boxplots
ggplot(data, aes(x = as.factor(soc.iso), y = peak.inf)) +
  geom_boxplot() +
  labs(title = "Effect of Social Isolation on Peak Infected",
       x = "Social Isolation Level", y = "Peak Infected")
```



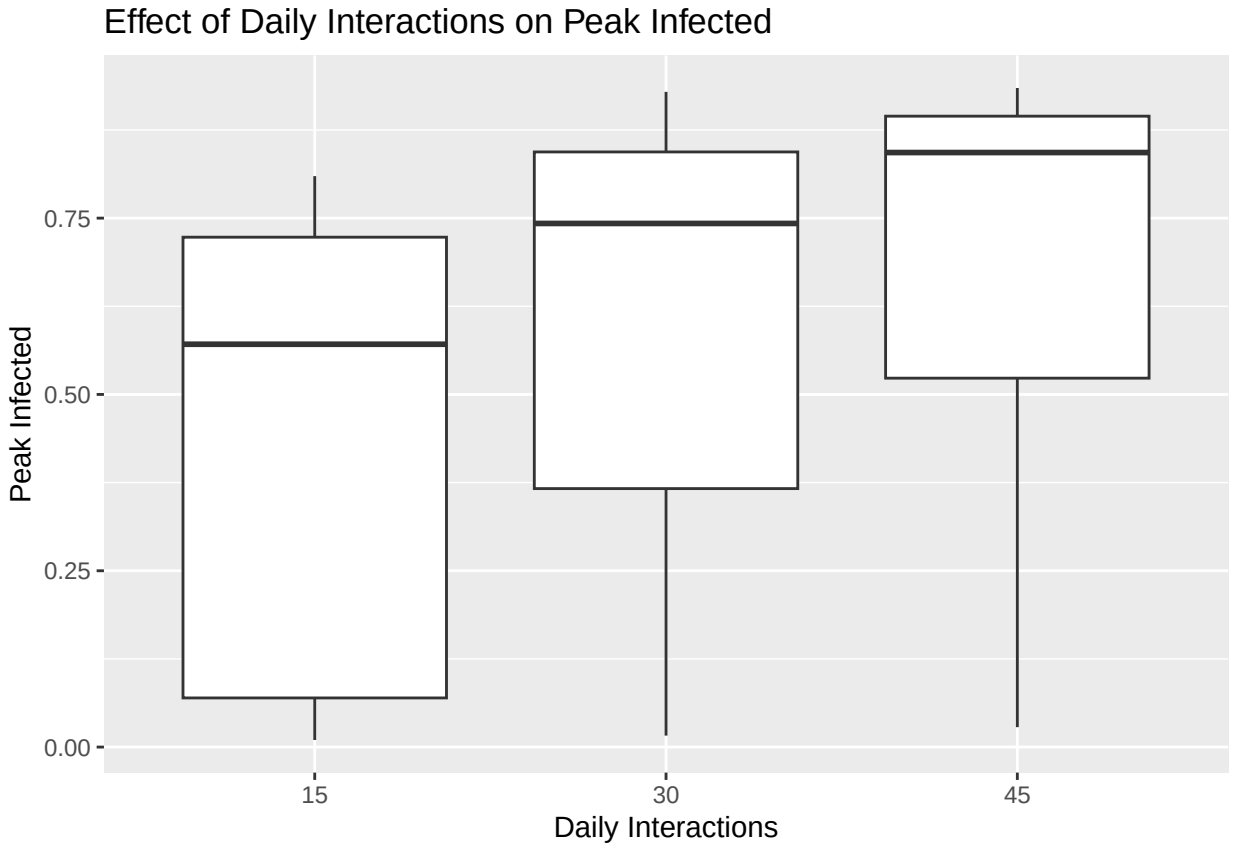

```
ggplot(data, aes(x = as.factor(rate.vac), y = peak.inf)) +
  geom_boxplot() +
  labs(title = "Effect of Vaccination Rate on Peak Infected",
       x = "Vaccination Rate", y = "Peak Infected")
```




```r
ggplot(data, aes(x = as.factor(quar.dur), y = peak.inf)) +
  geom_boxplot() +
  labs(title = "Effect of Quarantine Duration on Peak Infected",
    x = "Quarantine Duration (Days)", y = "Peak Infected")
```




```r
ggplot(data, aes(x = as.factor(num.daily), y = peak.inf)) +
  geom_boxplot() +
  labs(title = "Effect of Daily Interactions on Peak Infected",
    x = "Daily Interactions", y = "Peak Infected")
```




```
# Optimal Combination
aggregated_results <- aggregate(peak.inf ~ soc.iso + rate.vac + quar.dur + num.daily, data = data, mean)
optimal_combination <- aggregated_results[which.min(aggregated_results$peak.inf), ]
optimal_combination
```

```
##    soc.iso rate.vac quar.dur num.daily   peak.inf
## 18       1     0.02        7        15 0.01001624
```

```
# Treatment Contrasts
data$soc.iso <- as.factor(data$soc.iso)
data$rate.vac <- as.factor(data$rate.vac)
data$quar.dur <- as.factor(data$quar.dur)
data$num.daily <- as.factor(data$num.daily)
head(data)
```

```
##    peak.inf soc.iso rate.vac quar.dur num.daily
## 1 0.8071379       0        0        0        15
## 2 0.6471836     0.5        0        0        15
## 3 0.2764590       1        0        0        15
## 4 0.8095392       0     0.01        0        15
## 5 0.7619943     0.5     0.01        0        15
## 6 0.1626645       1     0.01        0        15
```

```
contrasts(data$soc.iso) <- contr.treatment(levels(data$soc.iso), base = 1)
contrasts(data$rate.vac) <- contr.treatment(levels(data$rate.vac), base = 1)
contrasts(data$quar.dur) <- contr.treatment(levels(data$quar.dur), base = 1)
contrasts(data$num.daily) <- contr.treatment(levels(data$num.daily), base = 1)

# Fit linear model with treatment contrasts
```

```r
lm_treatment <- lm(peak.inf ~ soc.iso + rate.vac + quar.dur + num.daily, data = data)
summary(lm_treatment)
```

```
##
## Call:
## lm(formula = peak.inf ~ soc.iso + rate.vac + quar.dur + num.daily,
##     data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.52037 -0.06863  0.00630  0.09649  0.22124
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.77483    0.04372  17.724  < 2e-16 ***
## soc.iso0.5   -0.11970    0.03569  -3.353  0.00128 **
## soc.iso1     -0.60227    0.03569 -16.873  < 2e-16 ***
## rate.vac0.01 -0.04030    0.03569  -1.129  0.26262
## rate.vac0.02 -0.02677    0.03569  -0.750  0.45574
## quar.dur7    -0.04085    0.03569  -1.145  0.25618
## quar.dur14   -0.18204    0.03569  -5.100 2.65e-06 ***
## num.daily30   0.17292    0.03569   4.844 7.06e-06 ***
## num.daily45   0.25645    0.03569   7.185 5.04e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1311 on 72 degrees of freedom
## Multiple R-squared:  0.8484, Adjusted R-squared:  0.8315
## F-statistic: 50.35 on 8 and 72 DF,  p-value: < 2.2e-16
```

```r
confint(lm_treatment, level = 0.95)
```

```
##                   2.5 %      97.5 %
## (Intercept)   0.68768351  0.86197623
## soc.iso0.5   -0.19085107 -0.04854165
## soc.iso1     -0.67342296 -0.53111354
## rate.vac0.01 -0.11145578  0.03085364
## rate.vac0.02 -0.09792289  0.04438652
## quar.dur7    -0.11200847  0.03030095
## quar.dur14   -0.25319013 -0.11088072
## num.daily30   0.10176193  0.24407134
## num.daily45   0.18529738  0.32760680
```

```r
coef_lm <- coef(lm_treatment)
coef_lm
```

```
##  (Intercept)   soc.iso0.5     soc.iso1 rate.vac0.01 rate.vac0.02    quar.dur7
##   0.77482987  -0.11969636  -0.60226825  -0.04030107  -0.02676818  -0.04085376
##   quar.dur14  num.daily30  num.daily45
##  -0.18203542   0.17291664   0.25645209
```

```r
confint_lm <- confint(lm_treatment)
confint_lm
```

```
##                   2.5 %      97.5 %
## (Intercept)   0.68768351  0.86197623
```

```
## soc.iso0.5   -0.19085107 -0.04854165
## soc.iso1     -0.67342296 -0.53111354
## rate.vac0.01 -0.11145578  0.03085364
## rate.vac0.02 -0.09792289  0.04438652
## quar.dur7    -0.11200847  0.03030095
## quar.dur14   -0.25319013 -0.11088072
## num.daily30   0.10176193  0.24407134
## num.daily45   0.18529738  0.32760680
```