ECO395M Final Project: Impact of Covid-19 on the flight delays and cancellation in California and Texas

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Abstract

This is our abstract.

Introduction

Methods

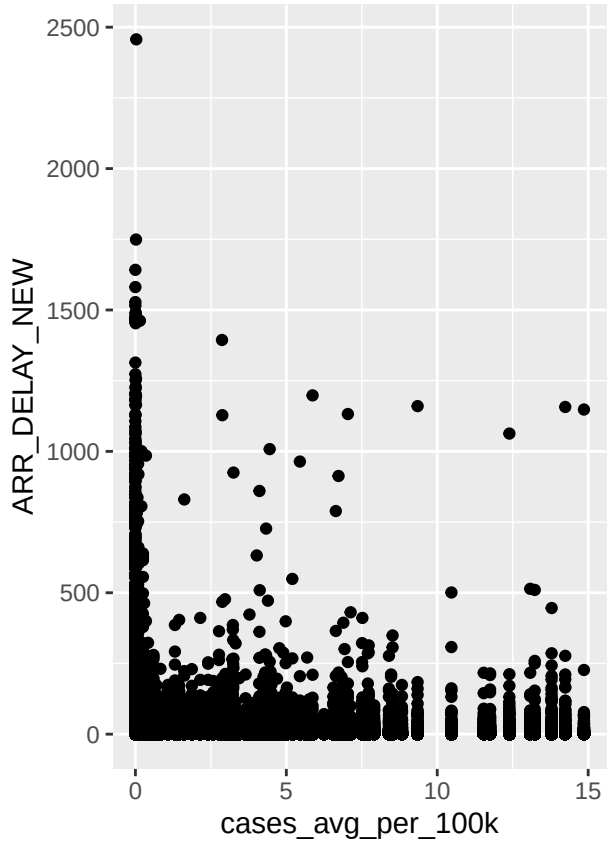
Dataset

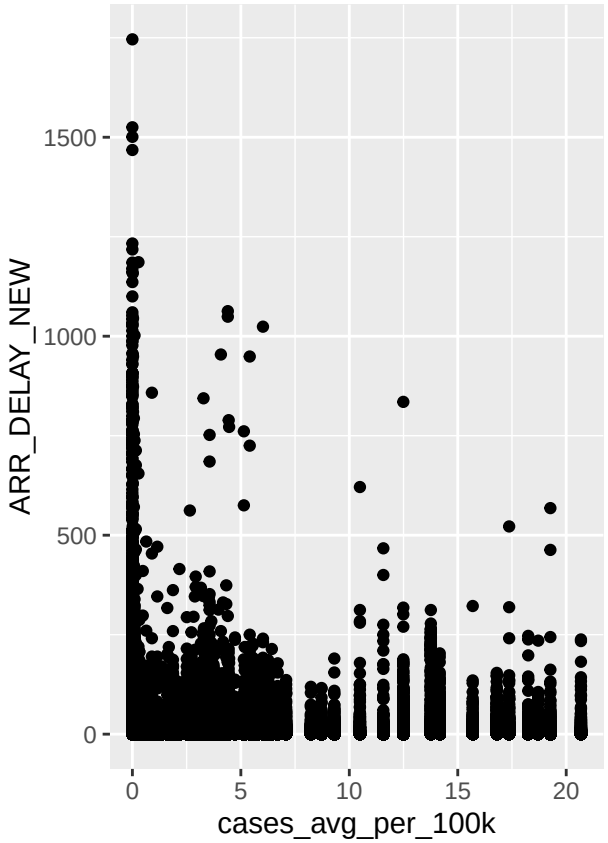
We have used 2 separate datasets and combined them to form a data frame that we used in the further analysis. The first dataset is from The United States Department of Transportation's (DOT) Bureau of Transportation Statistics tracks the on-time performance of domestic flights operated by large air carriers. The data collected is from January to June 2020 and contains relevant flight information (on-time, delayed, canceled, diverted flights) from the Top 10 United States flight carriers for 11 million flights. The second dataset is from the New York Times[2] which contains the state-wise data on the daily number of new cases and deaths, the seven-day rolling average, and the seven-day rolling average per 100,000 residents. We merged these two datasets based on the date and state to create a new dataset that we used in all the models. This combined dataset has in total of 2745847 observations with data from 375 different airports.

Data Wrangling

Data cleaning and preprocessing for the dataset was a four-step process. 1. Formatting the date field in both the individual datasets to match before performing a left join. 2. Merging the covid case dataset into the flight data based on date and state. 3. Factorizing the categorical variables from this combined dataset. `MONTH`, `DAY_OF_MONTH`, `DAY_OF_WEEK`, `MKT_UNIQUE_CARRIER`, `TAIL_NUM`, `ORIGIN`, `ORIGIN_STATE_NM`, `DEST`, `DEST_STATE_NM`, `ARR_DEL15`, `CANCELLED`, `CANCELLATION_CODE`, these are the categorical variables in the dataset. 4. Removing the variables that are not used in the analysis to have a cleaner dataset.

Airline Carrier Code: AA: American Airlines AS: Alaska Airlines B6: JetBlue DL: Delta Air Lines F9: Frontier Airlines G4: Allegiant Air HA: Hawaiian Airlines NK: Spirit Airlines UA: United Airlines WN: Southwest Airlines





	0
0	46658
1	4448

```
## [1] 0.9129652
```

	0
0	45517
1	5739

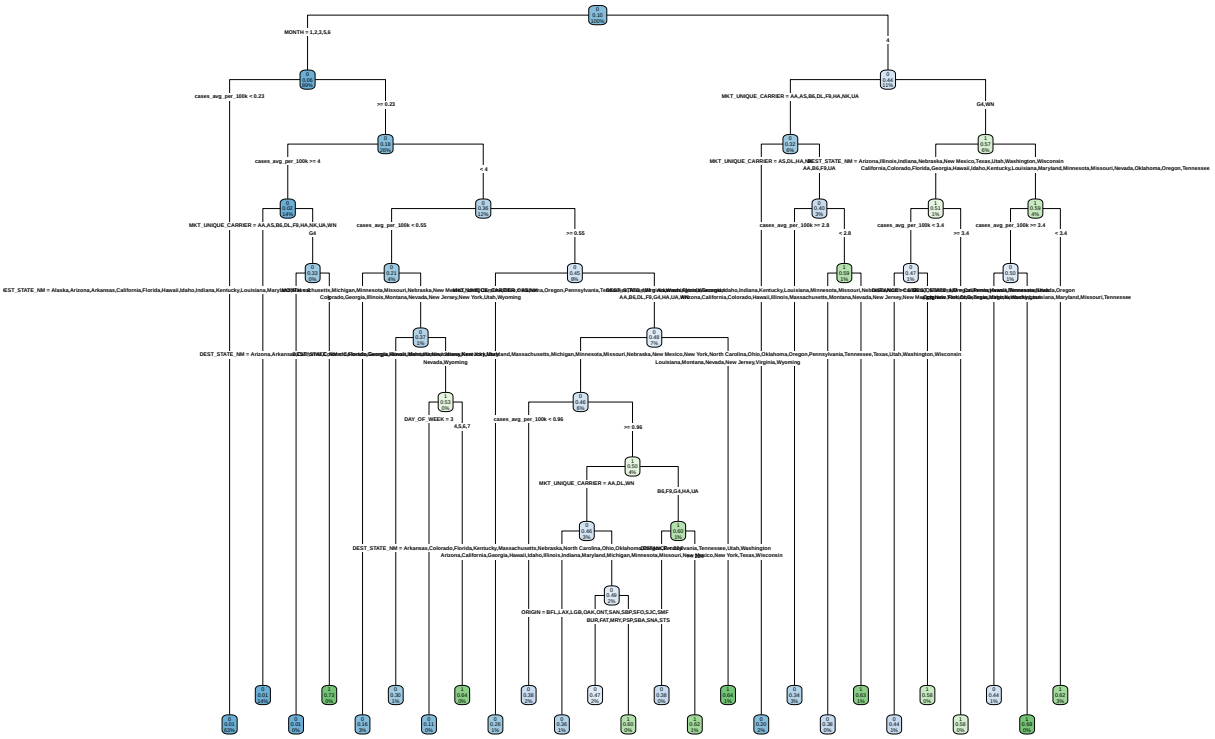
```
## [1] 0.8880326
```

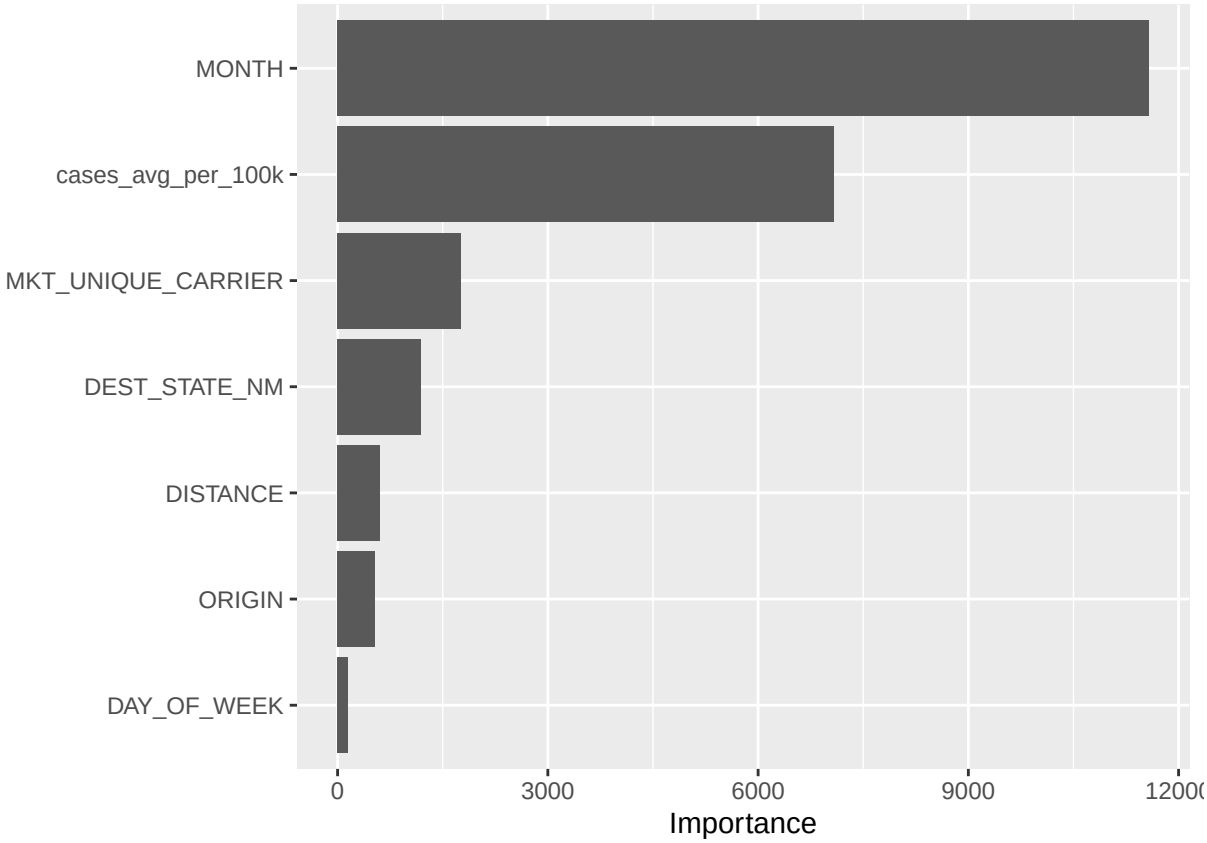
	0	1
0	49954	1233
1	4610	1192

```
## [1] 0.8974714
```

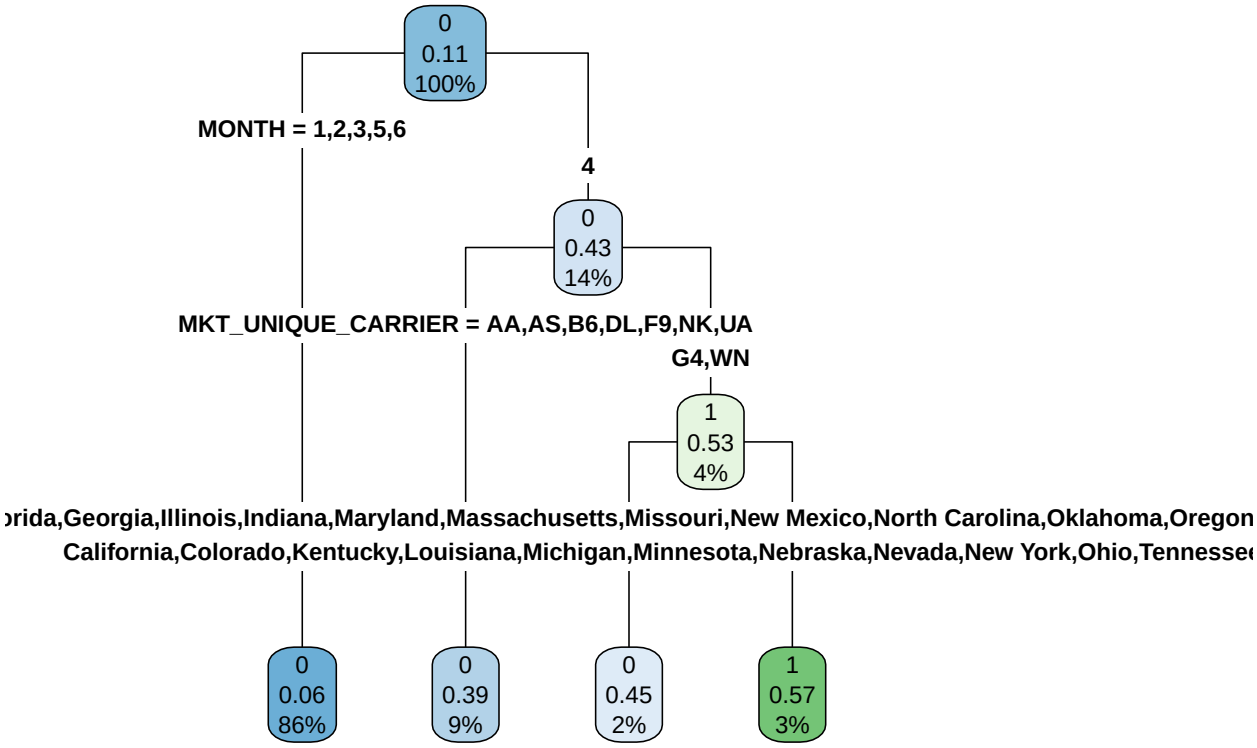
	0	1
0	49881	1449
1	5019	1190

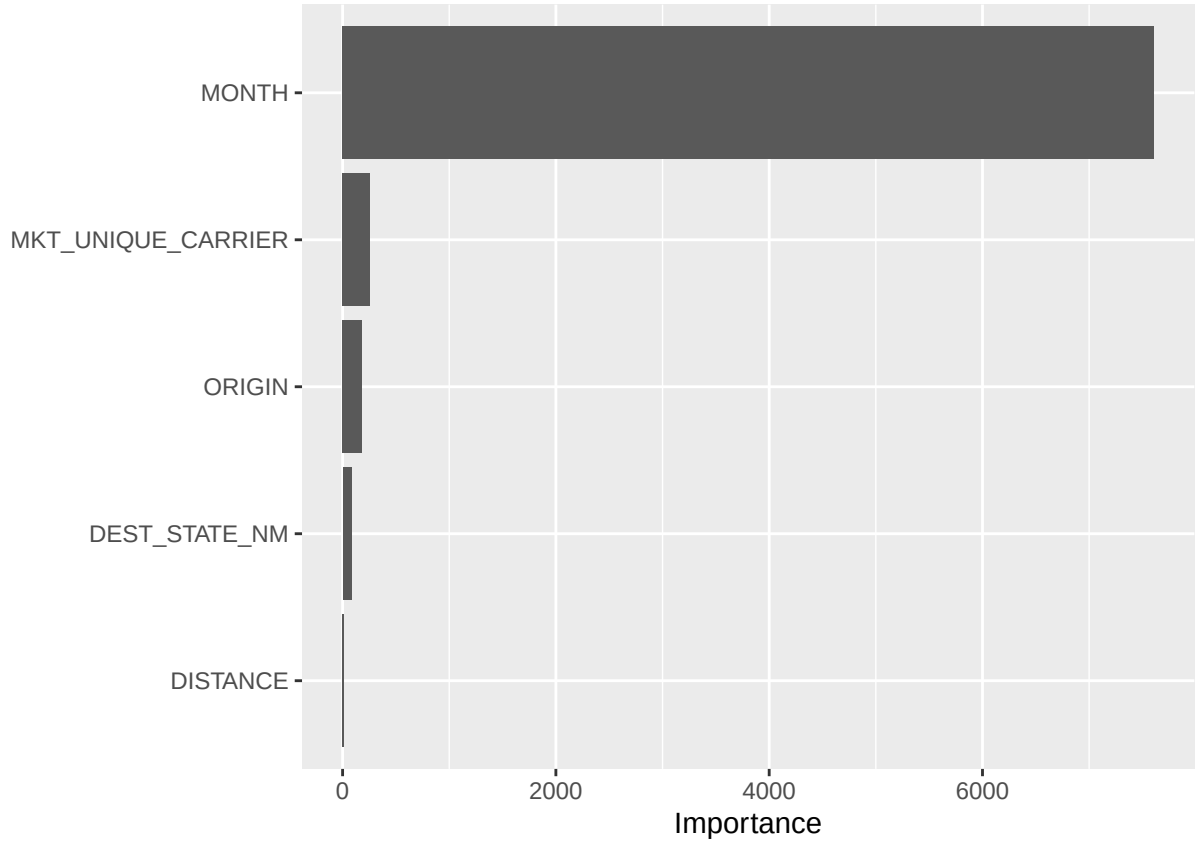
```
## [1] 0.8875893
```


MONTH = 1,2,3,5,6
4
cases_avg_per_100k < 0.23
>= 0.23
MKT_UNIQUE_CARRIER = AA,AS,B6,DL,F9,HA,NK,UA
G4,WN
cases_avg_per_100k >= 4
< 4
MKT_UNIQUE_CARRIER = AS,DL,HA,NK,AA,B6,F9,UA
DEST_STATE_NM = Arizona,Illinois,Indiana,Nebraska,New Mexico,Texas,Utah,Washington,Wisconsin
California,Colorado,Florida,Georgia,Hawaii,Idaho,Kentucky,Louisiana,Maryland,Minnesota,Missouri,Nevada,Oklahoma,Oregon,Tennessee
MKT_UNIQUE_CARRIER = AA,AS,B6,DL,F9,HA,NK,UA,WN
G4
cases_avg_per_100k < 0.55
>= 0.55
cases_avg_per_100k >= 2.8
< 2.8
cases_avg_per_100k < 3.4
>= 3.4
cases_avg_per_100k >= 3.4
< 3.4
DEST_STATE_NM = Arizona,Arkansas,California,Florida,Hawaii,Idaho,Indiana,Kentucky,Louisiana,Maryland,Missouri,Tennessee
Colorado,Georgia,Illinois,Montana,Nevada,New Jersey,New York,Utah,Wyoming
AA,B6,DL,F9,G4,HA,UA,WN
Arizona,California,Colorado,Hawaii,Illinois,Massachusetts,Montana,Nevada,New Jersey,New York,Oregon
Louisiana,Montana,Nevada,New Jersey,Virginia,Wyoming
DAY_OF_WEEK = 3
4,5,6,7
cases_avg_per_100k < 0.96
>= 0.96
MKT_UNIQUE_CARRIER = AA,DL,WN
B6,F9,G4,HA,UA
DEST_STATE_NM = Arkansas,Colorado,Florida,Kentucky,Massachusetts,Nebraska,North Carolina,Ohio,Oklahoma,Oregon,Pennsylvania,Tennessee,Utah,Washington
Arizona,California,Georgia,Hawaii,Idaho,Illinois,Indiana,Maryland,Michigan,Minnesota,Missouri,New Mexico,New York,Texas,Wisconsin
ORIGIN = BFI,LAX,LGB,OAK,ONT,SAN,SBP,SFO,SJC,SMF
BUR,PAT,MRY,PSP,SBA,SNA,STS


MONTH
cases_avg_per_100k
MKT_UNIQUE_CARRIER
DEST_STATE_NM
DISTANCE
ORIGIN
DAY_OF_WEEK
0
3000
6000
9000
12000
Importance

```
## [1] NaN
```


0
0.11
100%
MONTH = 1,2,3,5,6
4
0
0.43
14%
MKT_UNIQUE_CARRIER = AA,AS,B6,DL,F9,NK,UA
G4,WN
1
0.53
4%
rida,Georgia,Illinois,Indiana,Maryland,Massachusetts,Missouri,New Mexico,North Carolina,Oklahoma,Oregon
California,Colorado,Kentucky,Louisiana,Michigan,Minnesota,Nebraska,Nevada,New York,Ohio,Tennesse
0
0.06
86%
0
0.39
9%
0
0.45
2%
1
0.57
3%




```
## [1] NaN
```

```
##
## Call:
## lm(formula = ARR_DELAY_NEW ~ MONTH + DAY_OF_WEEK + MKT_UNIQUE_CARRIER +
##     DISTANCE + cases_avg_per_100k, data = airport_covid_California_train,
##     na.action = na.omit)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -19.85   -8.46   -5.28   -1.74 2448.26
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)          12.0743688  0.3281102  36.800  < 2e-16 ***
## MONTH2               -1.0876161  0.2100580  -5.178 2.25e-07 ***
## MONTH3               -3.0369516  0.2166941 -14.015  < 2e-16 ***
## MONTH4               -6.6555102  0.4343211 -15.324  < 2e-16 ***
## MONTH5               -7.2907144  0.5431907 -13.422  < 2e-16 ***
## MONTH6               -6.7338921  0.8741388  -7.703 1.33e-14 ***
## DAY_OF_WEEK2         -0.6149916  0.2859356  -2.151 0.031493 *
## DAY_OF_WEEK3         -1.0784439  0.2830749  -3.810 0.000139 ***
## DAY_OF_WEEK4          0.9951280  0.2807329   3.545 0.000393 ***
## DAY_OF_WEEK5          2.3069201  0.2808228   8.215  < 2e-16 ***
## DAY_OF_WEEK6          0.7335559  0.2966442   2.473 0.013405 *
## DAY_OF_WEEK7          0.9875795  0.2851250   3.464 0.000533 ***
## MKT_UNIQUE_CARRIERAS -2.9390253  0.2903774 -10.121  < 2e-16 ***
```

```
## MKT_UNIQUE_CARRIERB6 -2.7271487  0.5056591  -5.393 6.93e-08 ***
## MKT_UNIQUE_CARRIERDL -2.0629765  0.2943464  -7.009 2.41e-12 ***
## MKT_UNIQUE_CARRIERF9 -1.7145425  0.8743083  -1.961 0.049877 *
## MKT_UNIQUE_CARRIERG4  5.7020463  1.1127428   5.124 2.99e-07 ***
## MKT_UNIQUE_CARRIERHA -2.8714709  0.9511590  -3.019 0.002537 **
## MKT_UNIQUE_CARRIERNK -1.8322000  0.6859458  -2.671 0.007562 **
## MKT_UNIQUE_CARRIERUA -0.6002482  0.2609938  -2.300 0.021457 *
## MKT_UNIQUE_CARRIERWN -6.4179120  0.2504224 -25.628  < 2e-16 ***
## DISTANCE             -0.0008816  0.0001116  -7.902 2.75e-15 ***
## cases_avg_per_100k    0.1550709  0.0883141   1.756 0.079107 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 34.64 on 204144 degrees of freedom
##   (23785 observations deleted due to missingness)
## Multiple R-squared:  0.01101,    Adjusted R-squared:  0.0109
## F-statistic: 103.3 on 22 and 204144 DF,  p-value: < 2.2e-16
```

```
## [1] 35.59012
```

```
## [1] 30.88132
```

Beta coefficient = 0.1170830. The partial effect of cases_avg_per_100k on the airline delay.

```
##
## Call:
## zeroinfl(formula = ARR_DELAY_NEW ~ MONTH + DAY_OF_WEEK + MKT_UNIQUE_CARRIER +
##     DISTANCE + cases_avg_per_100k | cases_avg_per_100k, data = airport_covid_California_train,
##     na.action = na.omit)
##
## Pearson residuals:
##      Min       1Q   Median       3Q      Max
##  -0.5175  -0.5130  -0.5060  -0.3504 184.9713
##
## Count model coefficients (poisson with log link):
##                         Estimate Std. Error  z value Pr(>|z|)
## (Intercept)           3.846e+00  3.393e-03 1133.464  < 2e-16 ***
## MONTH2                5.598e-03  2.114e-03    2.648 0.008092 **
## MONTH3               -2.842e-02  2.365e-03  -12.016  < 2e-16 ***
## MONTH4                5.806e-02  7.332e-03    7.918 2.42e-15 ***
## MONTH5               -5.015e-01  9.376e-03  -53.485  < 2e-16 ***
## MONTH6               -8.763e-01  1.495e-02  -58.631  < 2e-16 ***
## DAY_OF_WEEK2          2.366e-02  3.511e-03    6.737 1.61e-11 ***
## DAY_OF_WEEK3         -1.256e-01  3.532e-03  -35.557  < 2e-16 ***
## DAY_OF_WEEK4         -3.408e-02  3.209e-03  -10.619  < 2e-16 ***
## DAY_OF_WEEK5          7.111e-02  3.093e-03   22.991  < 2e-16 ***
## DAY_OF_WEEK6          1.204e-01  3.399e-03   35.436  < 2e-16 ***
## DAY_OF_WEEK7          7.665e-02  3.254e-03   23.553  < 2e-16 ***
## MKT_UNIQUE_CARRIERAS -3.833e-01  3.035e-03 -126.301  < 2e-16 ***
## MKT_UNIQUE_CARRIERB6 -1.165e-01  5.631e-03  -20.688  < 2e-16 ***
## MKT_UNIQUE_CARRIERDL -1.469e-01  3.005e-03  -48.890  < 2e-16 ***
## MKT_UNIQUE_CARRIERF9 -1.522e-01  8.908e-03  -17.081  < 2e-16 ***
## MKT_UNIQUE_CARRIERG4  1.385e-01  8.389e-03   16.513  < 2e-16 ***
## MKT_UNIQUE_CARRIERHA -4.191e-02  1.152e-02   -3.638 0.000275 ***
## MKT_UNIQUE_CARRIERNK -1.226e-01  7.118e-03  -17.229  < 2e-16 ***
## MKT_UNIQUE_CARRIERUA  9.285e-02  2.491e-03   37.276  < 2e-16 ***
```

```
## MKT_UNIQUE_CARRIERWN -7.418e-01  3.025e-03 -245.260  < 2e-16 ***
## DISTANCE             -1.356e-04  8.564e-07 -158.386  < 2e-16 ***
## cases_avg_per_100k    5.048e-02  1.393e-03   36.235  < 2e-16 ***
##
## Zero-inflation model coefficients (binomial with logit link):
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        1.296026   0.006114  211.97   <2e-16 ***
## cases_avg_per_100k 0.111545   0.002519   44.28   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Number of iterations in BFGS optimization: 1
## Log-likelihood: -1.332e+06 on 25 Df
```

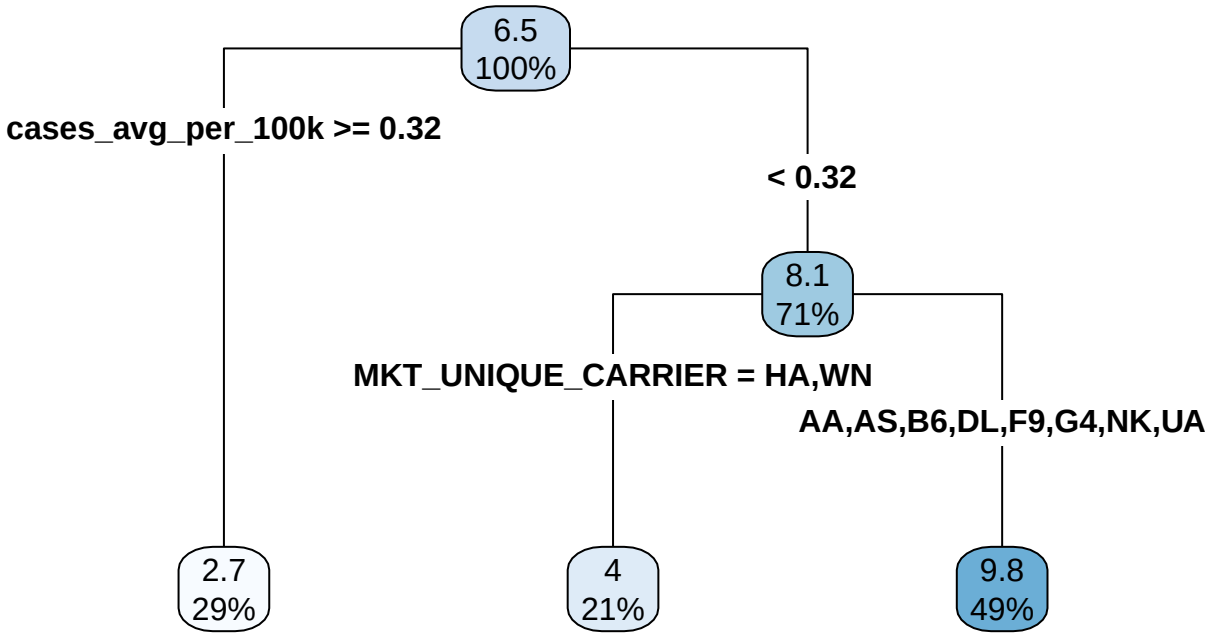
```
## [1] 35.51814
```

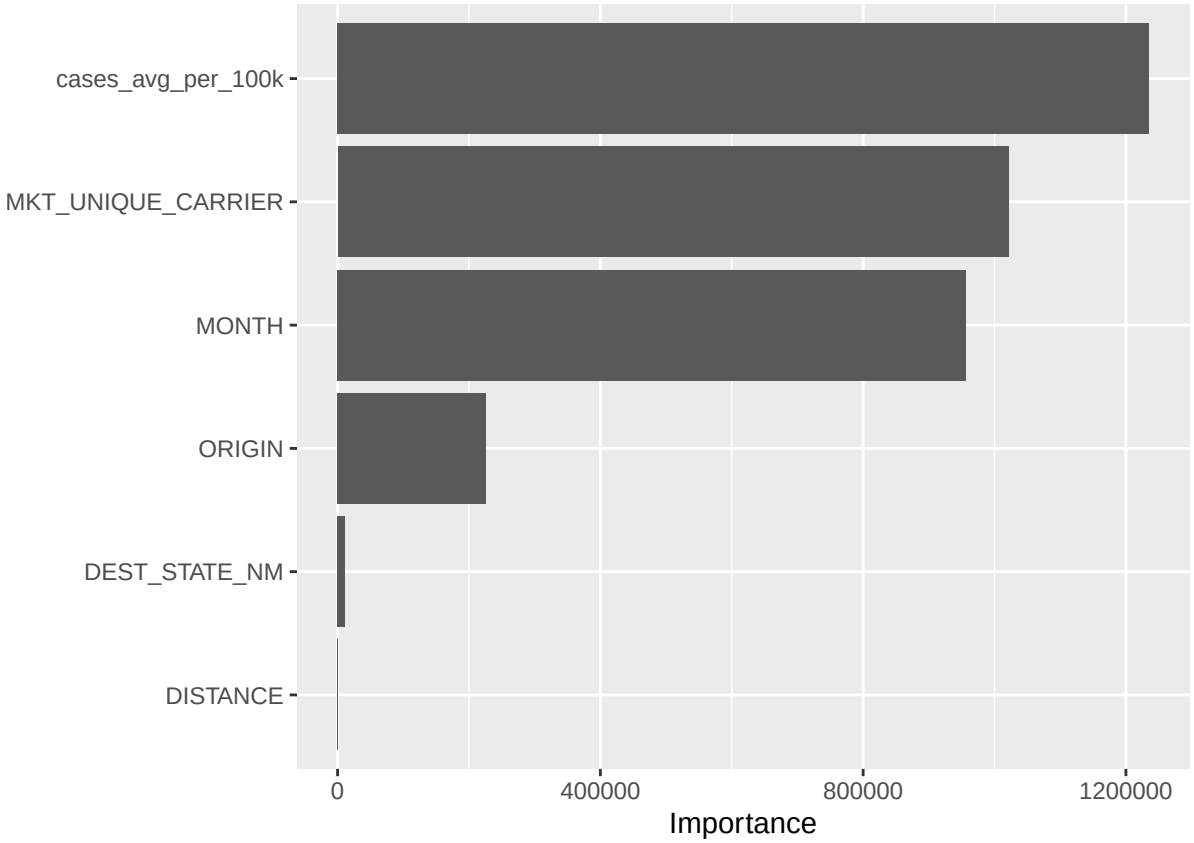
```
##
## Call:
## zeroinfl(formula = ARR_DELAY_NEW ~ MONTH + DAY_OF_WEEK + MKT_UNIQUE_CARRIER +
##     DISTANCE + cases_avg_per_100k | cases_avg_per_100k, data = airport_covid_Texas_train,
##     na.action = na.omit)
##
## Pearson residuals:
##      Min       1Q   Median       3Q      Max
##  -0.5637  -0.5590  -0.5514  -0.4566 117.7892
##
## Count model coefficients (poisson with log link):
##                         Estimate Std. Error  z value Pr(>|z|)
## (Intercept)           3.657e+00  2.727e-03 1340.716  < 2e-16 ***
## MONTH2               -1.320e-01  2.073e-03  -63.703  < 2e-16 ***
## MONTH3               -7.932e-02  2.214e-03  -35.831  < 2e-16 ***
## MONTH4               -3.431e-01  4.773e-03  -71.881  < 2e-16 ***
## MONTH5               -3.762e-01  4.486e-03  -83.867  < 2e-16 ***
## MONTH6               -5.321e-01  7.175e-03  -74.161  < 2e-16 ***
## DAY_OF_WEEK2         -1.666e-01  3.248e-03  -51.290  < 2e-16 ***
## DAY_OF_WEEK3         -1.169e-01  3.089e-03  -37.839  < 2e-16 ***
## DAY_OF_WEEK4         -1.998e-02  2.850e-03   -7.012 2.36e-12 ***
## DAY_OF_WEEK5          4.488e-02  2.809e-03   15.979  < 2e-16 ***
## DAY_OF_WEEK6          1.171e-02  3.130e-03    3.742 0.000182 ***
## DAY_OF_WEEK7         -3.954e-02  3.023e-03  -13.077  < 2e-16 ***
## MKT_UNIQUE_CARRIERAS -1.931e-01  7.783e-03  -24.812  < 2e-16 ***
## MKT_UNIQUE_CARRIERB6  2.186e-01  1.162e-02   18.813  < 2e-16 ***
## MKT_UNIQUE_CARRIERDL  1.710e-01  3.682e-03   46.441  < 2e-16 ***
## MKT_UNIQUE_CARRIERF9  3.831e-01  9.809e-03   39.054  < 2e-16 ***
## MKT_UNIQUE_CARRIERG4  3.118e-01  1.111e-02   28.064  < 2e-16 ***
## MKT_UNIQUE_CARRIERNK  1.004e-01  5.711e-03   17.581  < 2e-16 ***
## MKT_UNIQUE_CARRIERUA  7.508e-02  1.987e-03   37.790  < 2e-16 ***
## MKT_UNIQUE_CARRIERWN -4.269e-01  2.605e-03 -163.918  < 2e-16 ***
## DISTANCE             -3.763e-05  1.416e-06  -26.582  < 2e-16 ***
## cases_avg_per_100k    2.035e-02  5.590e-04   36.408  < 2e-16 ***
##
## Zero-inflation model coefficients (binomial with logit link):
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        1.123907   0.005714  196.68   <2e-16 ***
## cases_avg_per_100k 0.028292   0.001567   18.05   <2e-16 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Number of iterations in BFGS optimization: 1
## Log-likelihood: -1.473e+06 on 24 Df
```

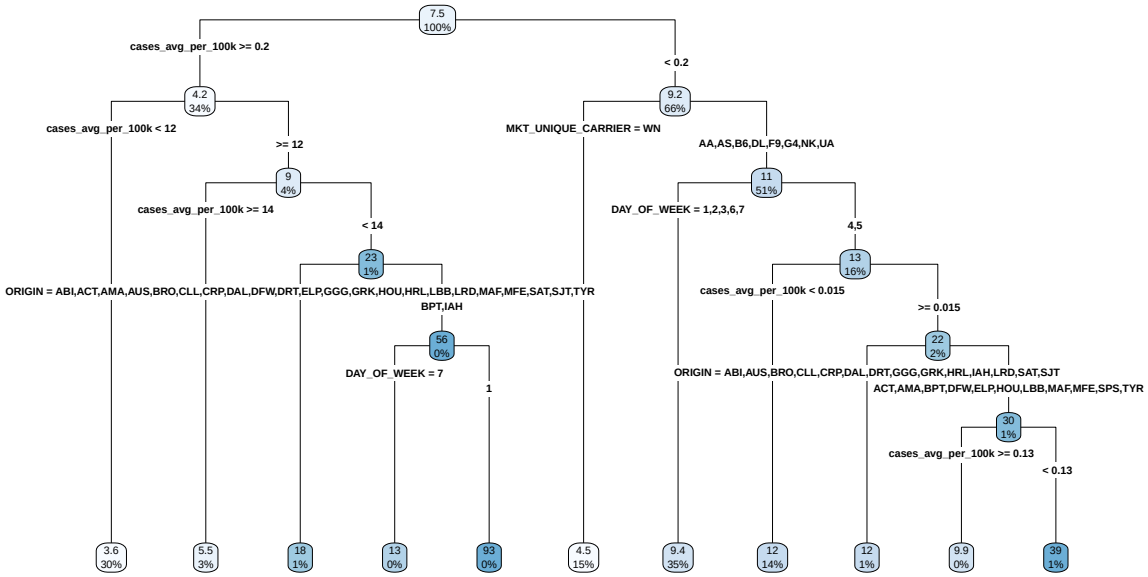
```
## [1] 30.88815
```

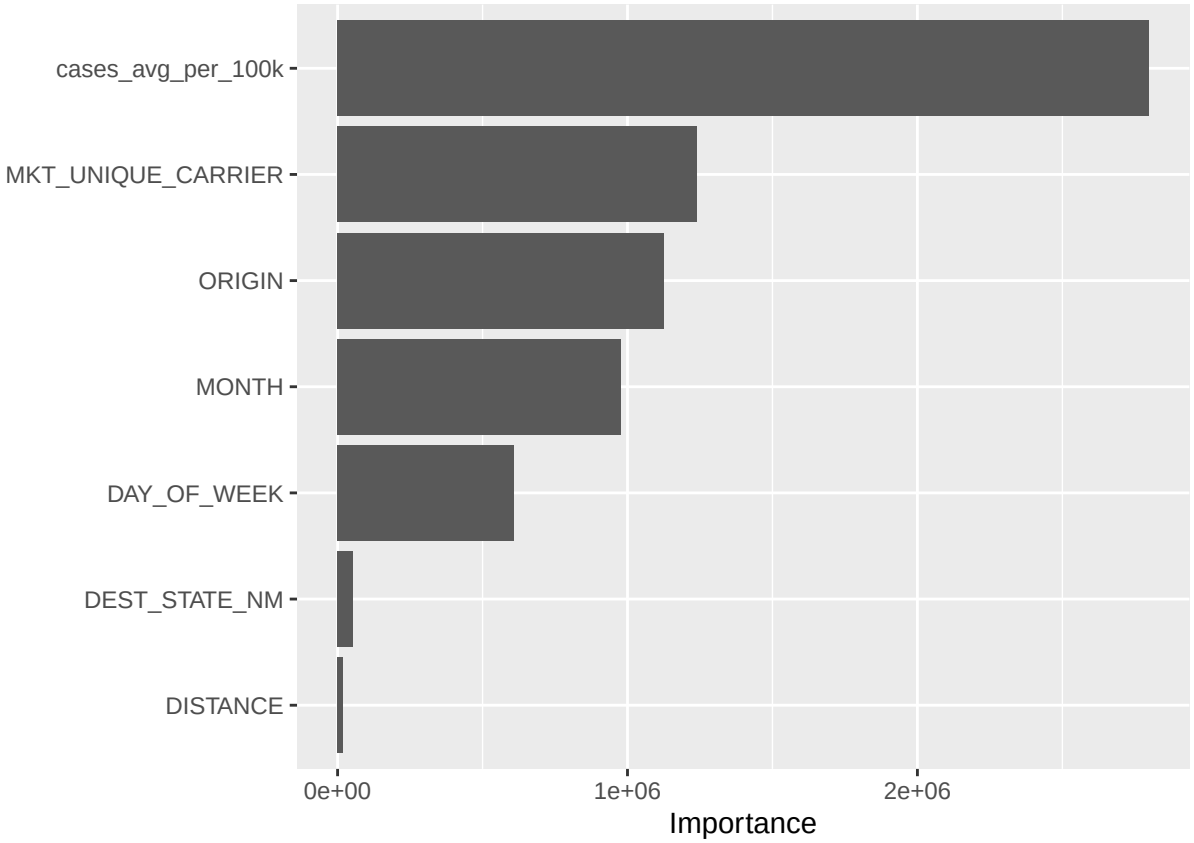
For the zero-inflated poisson model, the first process generates zeros and the second process is governed by a Poisson distribution that generates counts, some of which may be zero. In this model building, the assumption is that the covid cases would generate the non-zero counts.




cases_avg_per_100k
MKT_UNIQUE_CARRIER
MONTH
ORIGIN
DEST_STATE_NM
DISTANCE
0
400000
800000
1200000
Importance

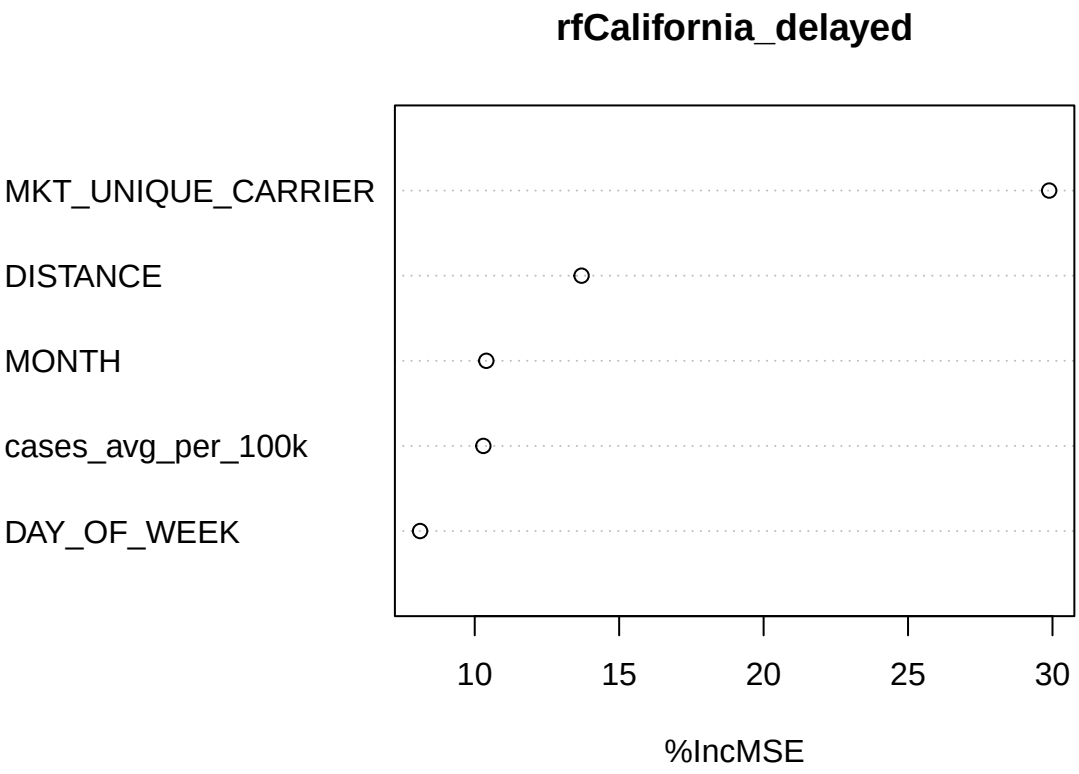
```
## [1] 35.22869
```

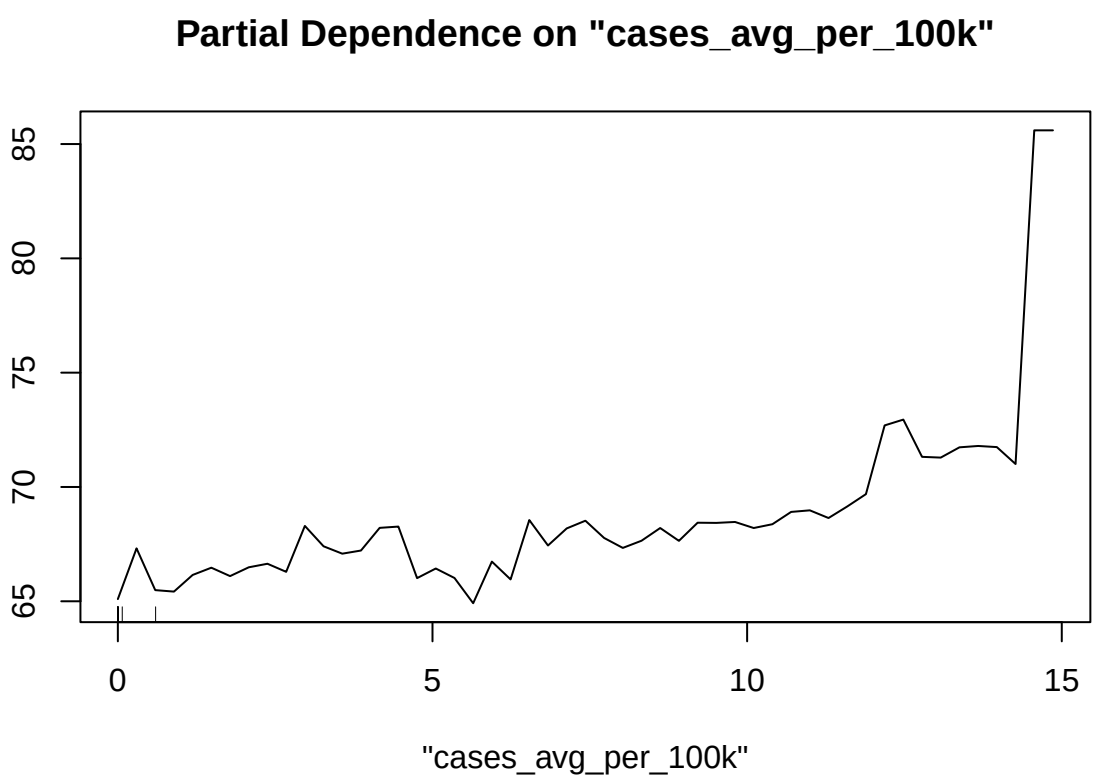

7.5
100%
cases_avg_per_100k >= 0.2
< 0.2
4.2
34%
9.2
66%
cases_avg_per_100k < 12
>= 12
MKT_UNIQUE_CARRIER = WN
AA,AS,B6,DL,F9,G4,NK,UA
9
4%
11
51%
cases_avg_per_100k >= 14
< 14
DAY_OF_WEEK = 1,2,3,6,7
4,5
23
1%
13
16%
ORIGIN = ABI,ACT,AMA,AUS,BRO,CLL,CRP,DAL,DFW,DRT,ELP,GGG,GRK,HOU,HRL,LBB,LRD,MAF,MFE,SAT,SJT,TYR
BPT,IAH
cases_avg_per_100k < 0.015
>= 0.015
56
0%
22
2%
DAY_OF_WEEK = 7
1
ORIGIN = ABI,AUS,BRO,CLL,CRP,DAL,DRT,GGG,GRK,HRL,IAH,LRD,SAT,SJT
ACT,AMA,BPT,DFW,ELP,HOU,LBB,MAF,MFE,SPS,TYR
30
1%
cases_avg_per_100k >= 0.13
< 0.13
3.6
30%
5.5
3%
18
1%
13
0%
93
0%
4.5
15%
9.4
35%
12
14%
12
1%
9.9
0%
39
1%



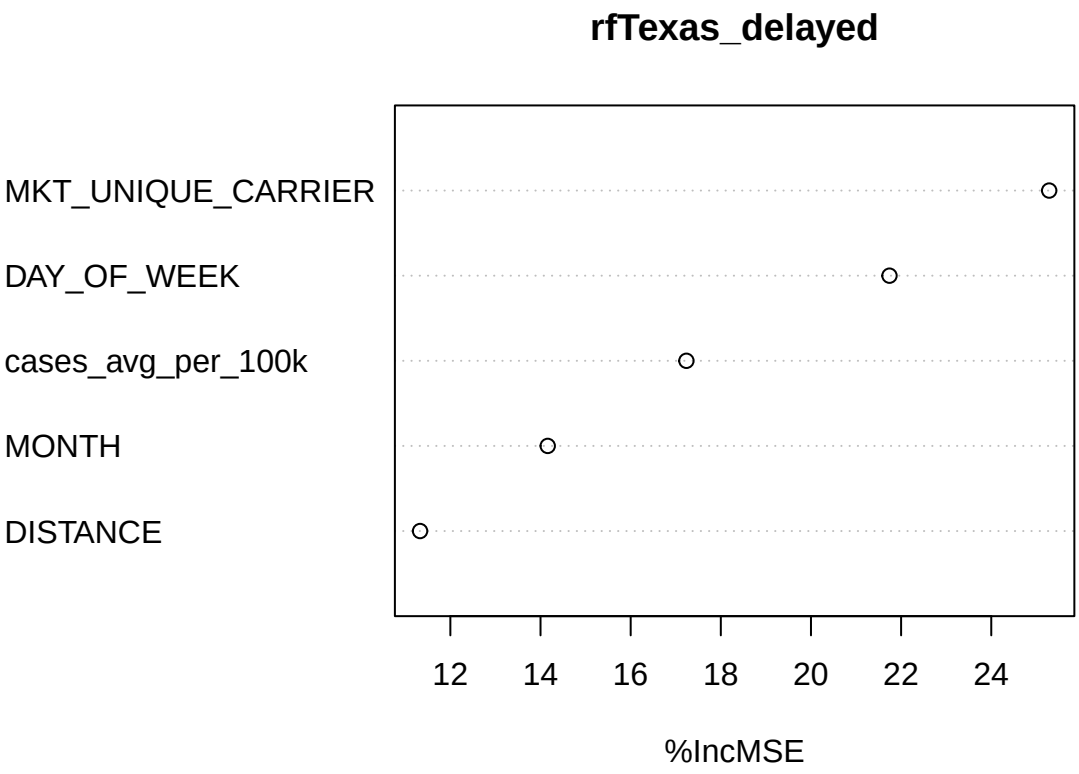

```
## [1] 30.32028
```

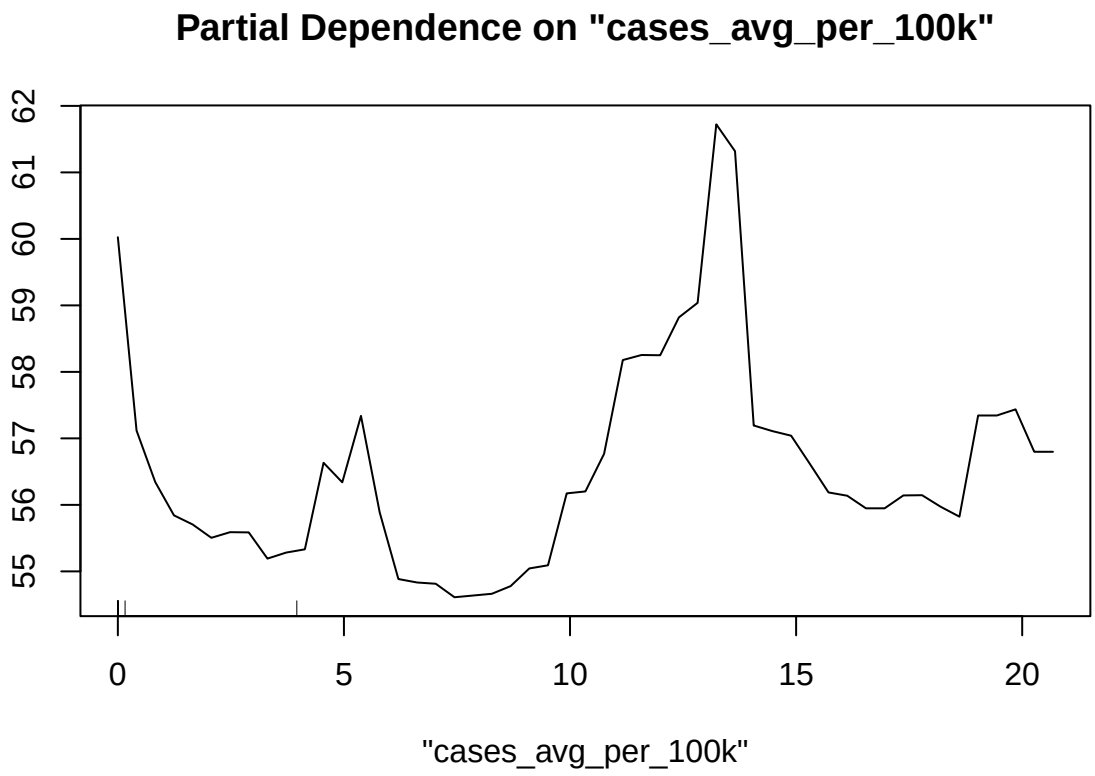
```
## [1] 98.84347
```


rfCalifornia_delayed
MKT_UNIQUE_CARRIER
DISTANCE
MONTH
cases_avg_per_100k
DAY_OF_WEEK
10
15
20
25
30
%IncMSE


Partial Dependence on "cases_avg_per_100k"
65
70
75
80
85
0
5
10
15
"cases_avg_per_100k"

```
## [1] 82.96199
```


rfTexas_delayed
MKT_UNIQUE_CARRIER
DAY_OF_WEEK
cases_avg_per_100k
MONTH
DISTANCE
12
14
16
18
20
22
24
%IncMSE



Including `ORIGIN` only reduced the rMSE from 97.35954 to 97.20708. removing the variable for the entire country analysis, as there are too many levels.