Time series analysis with updated window definition

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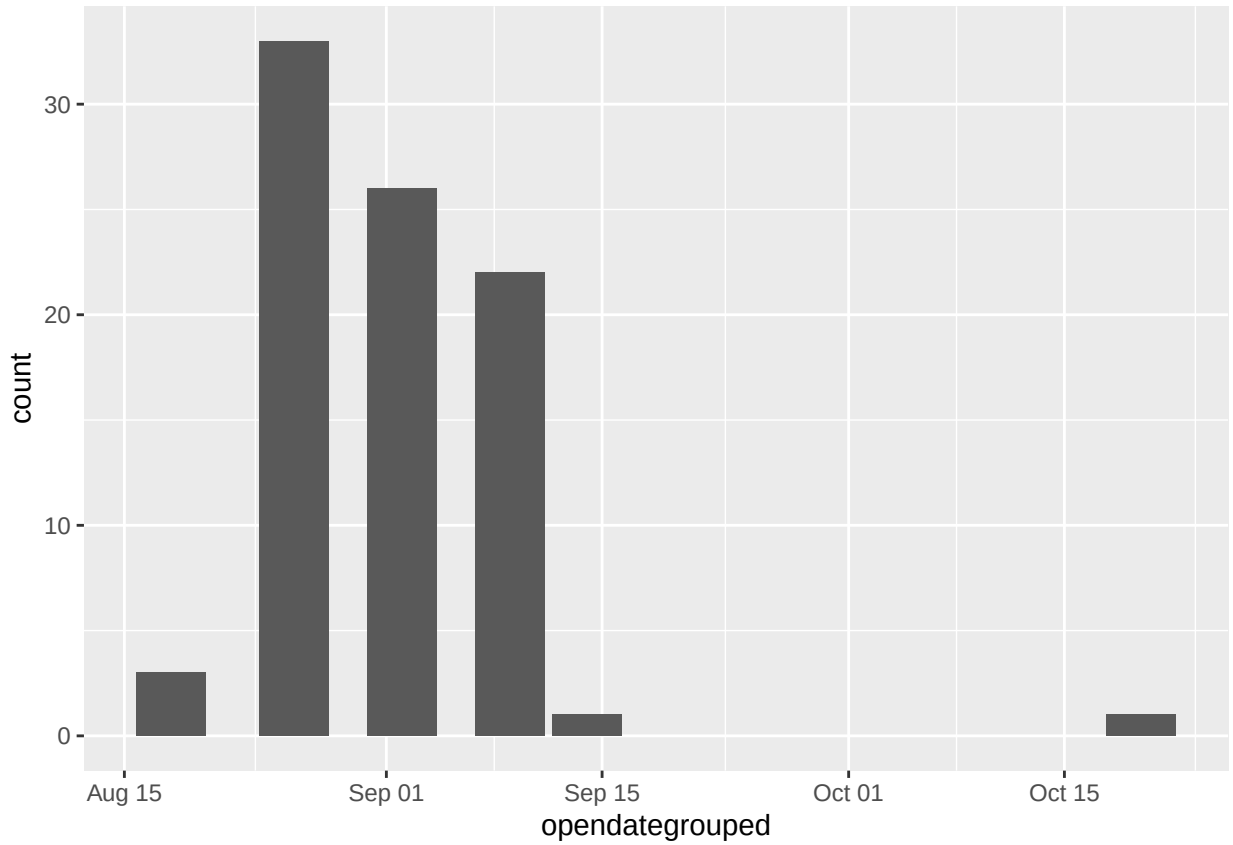
Select varible of interests

```
## If you don't have the covidcast package, run following line

#devtools::install_github("cmu-delphi/covidcast", ref = "main", subdir = "R-packages/covidcast",depende
```

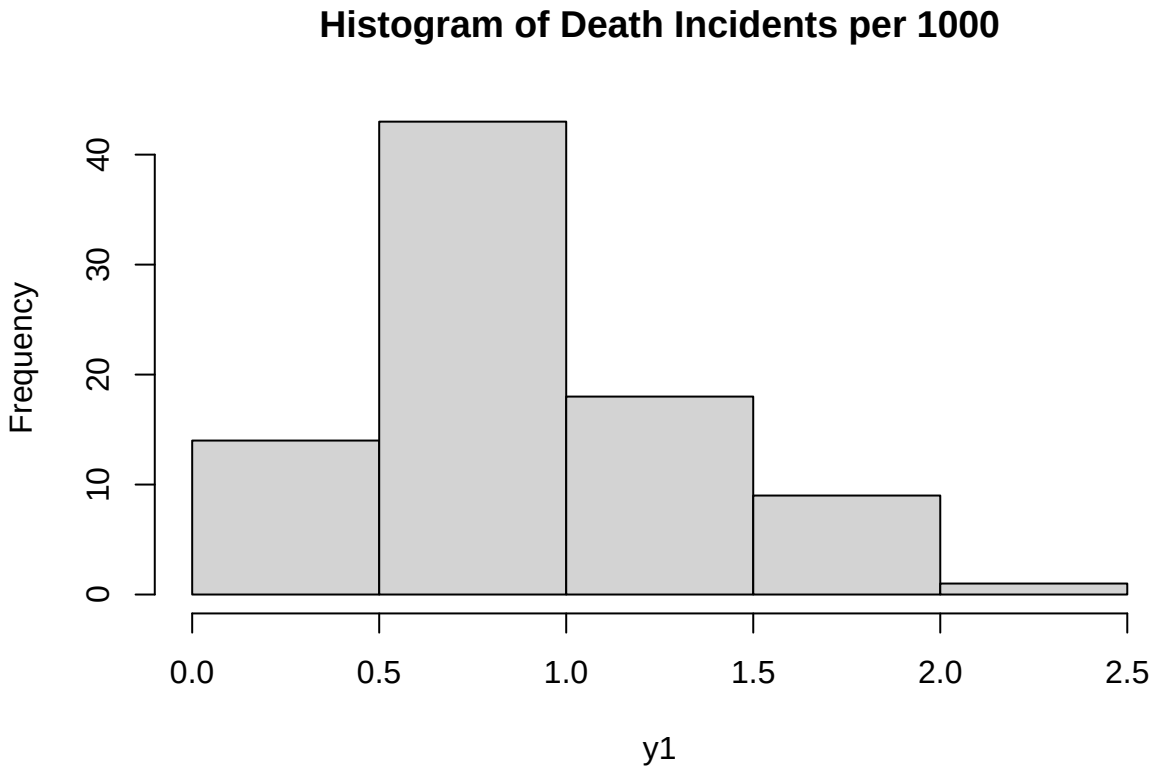
```
source("step2_data_wrangle.R")

################### school reopen dates ###################
district_policies <- OH_K12 %>%
  distinct(county,county_enroll,leaid,district_enroll,schooltemporaryshutdown,opendategrouped,teachingm

# Calculate the proportion and generate date brackets
major_opendate <- district_policies%>%
  filter(!schooltemporaryshutdown %in% c('Closed indefinitely','Pending','Unknown'))%>%
  group_by(county,county_enroll,opendategrouped)%>%
  summarise(n_opendate = sum(district_enroll))%>% # number of students under certain date for each coun
  mutate(prop_opendate = round(n_opendate/county_enroll,2))%>% # proportion
  group_by(county)%>%
  #filter(prop_opendate>0.6)%>%
  slice(which.max(prop_opendate))%>% # filter large proportions of students with same reopen dates #can
  mutate(reopen_3w_after = opendategrouped + 21)%>%
  select(-n_opendate)

major_opendate%>%
  ggplot(aes(x=opendategrouped))+geom_bar(stat="count")
```



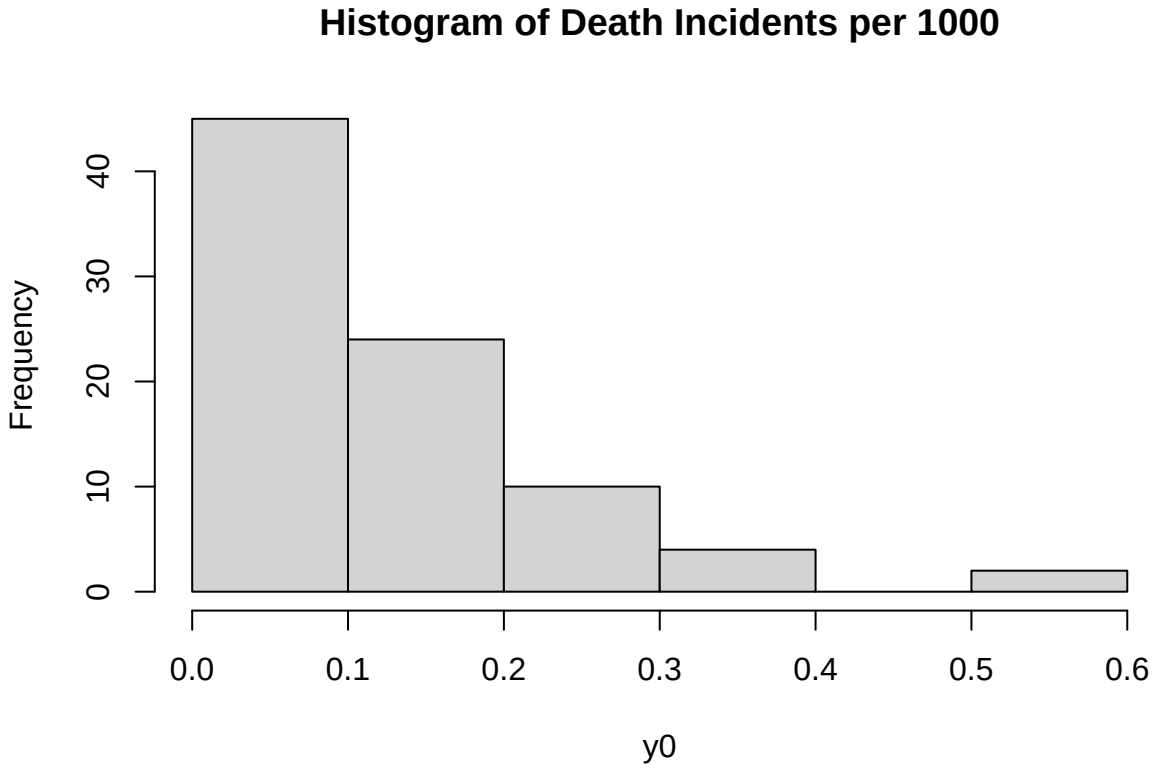

```
opendate_deaths <- case_mobility%>%
  inner_join(major_opendate,by=c('COUNTY'='county'))%>%
  group_by(COUNTY)%>%
  filter(opendategrouped < as.Date("2020-10-15"))%>% ## drop late open dates
  filter(DATE>=reopen_3w_after - 56 & DATE<= as.Date('2020-12-25'))%>% # window with 56 days
  ungroup()%>%
  mutate(window_id = case_when(
    DATE <= reopen_3w_after~"2month_before_3wafteropen",
    reopen_3w_after < DATE ~"2month_after_3wafteropen",
    TRUE ~ 'Other'))%>%
  mutate(death_per_1000 = round(CUMDEATHS/POPULATION,5)*1000,case_per_1000 = round(CUMCONFIRMED/POPULATI
         window_id = as.factor(window_id))%>%
  left_join(wide_teaching_enroll,by=c('COUNTY'='county','county_enroll'))
# select the start date and end date data for each window of time

death_incidence_window <- opendate_deaths%>%
  group_by(COUNTY,window_id)%>%
  arrange(DATE)%>%
  mutate(avg_full_work = mean(full_work_prop_7d,na.rm = T),avg_part_work =mean(part_work_prop_7d,na.rm =
  filter(row_number()==1 | row_number()==n())%>%
  mutate(death_incidence = diff(CUMDEATHS),death_incidence_per_1000 = diff(CUMDEATHS)*1000/POPULATION)%
  distinct(COUNTY,POPULATION,avg_full_work,avg_part_work,avg_res_visit,avg_bar_visit,Online_Only,On_Pre
```

```
y1y0 <- death_incidence_window %>%
  filter(window_id!='Other')%>%
  group_by(COUNTY)%>%
  mutate(y1= death_incidence_per_1000, y0 = lag(death_incidence_per_1000,n=1))%>%
```

```
  drop_na(y0)

hist(y1y0$y1,main = "Histogram of Death Incidents per 1000", xlab = "y1")
```




```
hist(y1y0$y0,main = "Histogram of Death Incidents per 1000", xlab = "y0")
```



```r
summary(lm(y1~y0,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.6967 -0.3165 -0.0902  0.1899  1.5490
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.90769    0.06558  13.841   <2e-16 ***
## y0          -0.15996    0.39370  -0.406    0.686
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4228 on 83 degrees of freedom
## Multiple R-squared:  0.001985,   Adjusted R-squared:  -0.01004
## F-statistic: 0.1651 on 1 and 83 DF,  p-value: 0.6856
```

```r
summary(lm(y1~POPULATION,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ POPULATION, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.71190 -0.27760 -0.06764  0.16383  1.51245
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  9.509e-01  5.253e-02  18.102   <2e-16 ***
## POPULATION  -4.524e-07  2.021e-07  -2.239   0.0278 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.411 on 83 degrees of freedom
## Multiple R-squared:  0.05695,    Adjusted R-squared:  0.04559
## F-statistic: 5.013 on 1 and 83 DF,  p-value: 0.02784
```

```r
summary(lm(y1~avg_full_work,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_full_work, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.67423 -0.26672 -0.06998  0.25765  1.11840
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.5203     0.3659  -1.422 0.158766
```

```
## avg_full_work  24.9466     6.4354   3.876 0.000211 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3894 on 83 degrees of freedom
## Multiple R-squared:  0.1533, Adjusted R-squared:  0.1431
## F-statistic: 15.03 on 1 and 83 DF,  p-value: 0.0002111
```

```
summary(lm(y1~avg_part_work,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_part_work, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.57580 -0.29662 -0.03869  0.21696  1.49645
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.5742     0.4407  -1.303  0.19622
## avg_part_work  17.0102     5.1000   3.335  0.00128 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3974 on 83 degrees of freedom
## Multiple R-squared:  0.1182, Adjusted R-squared:  0.1076
## F-statistic: 11.12 on 1 and 83 DF,  p-value: 0.001276
```

```
summary(lm(y1~y0+avg_full_work,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.76230 -0.29059 -0.04193  0.28485  0.99880
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.6086     0.3672  -1.657    0.101
## y0             -0.5821     0.3734  -1.559    0.123
## avg_full_work  27.7365     6.6269   4.185 7.11e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3861 on 82 degrees of freedom
## Multiple R-squared:  0.1777, Adjusted R-squared:  0.1576
## F-statistic: 8.858 on 2 and 82 DF,  p-value: 0.0003289
```

```
summary(lm(y1~y0+avg_part_work,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_part_work, data = y1y0, na.action = "na.omit")
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.64096 -0.27303 -0.03683  0.17002  1.43457
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.6456     0.4431  -1.457 0.148966
## y0             -0.4676     0.3790  -1.234 0.220863
## avg_part_work  18.4877     5.2232   3.540 0.000664 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3962 on 82 degrees of freedom
## Multiple R-squared:  0.1343, Adjusted R-squared:  0.1131
## F-statistic: 6.358 on 2 and 82 DF,  p-value: 0.00271
```

```
summary(lm(y1~y0+avg_full_work+avg_part_work,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work + avg_part_work, data = y1y0,
##     na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.64079 -0.28582 -0.04847  0.24425  1.08347
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.8760     0.4425  -1.980   0.0511 .
## y0             -0.6060     0.3737  -1.622   0.1088
## avg_full_work  21.1353     9.0082   2.346   0.0214 *
## avg_part_work   7.4773     6.9198   1.081   0.2831
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3857 on 81 degrees of freedom
## Multiple R-squared:  0.1893, Adjusted R-squared:  0.1593
## F-statistic: 6.307 on 3 and 81 DF,  p-value: 0.0006722
```

```
summary(lm(y1~y0+avg_res_visit,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_res_visit, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.6815 -0.2985 -0.0840  0.2055  1.4691
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.0503123  0.0982905  10.686   <2e-16 ***
## y0            -0.1655649  0.3952144  -0.419   0.6764
```

```
## avg_res_visit -0.0004437  0.0002458  -1.805   0.0748 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4193 on 80 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.0421, Adjusted R-squared:  0.01816
## F-statistic: 1.758 on 2 and 80 DF,  p-value: 0.179
```

```
summary(lm(y1~y0+avg_bar_visit,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_bar_visit, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.24777 -0.10751  0.01474  0.10251  0.27331
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.4776285  0.1068730   4.469  0.00053 ***
## y0             1.5481188  0.6409516   2.415  0.02997 *
## avg_bar_visit -0.0004818  0.0006302  -0.764  0.45728
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1623 on 14 degrees of freedom
##   (68 observations deleted due to missingness)
## Multiple R-squared:  0.4179, Adjusted R-squared:  0.3348
## F-statistic: 5.026 on 2 and 14 DF,  p-value: 0.02264
```

```
summary(lm(y1~y0+Hybrid,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Hybrid, data = y1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.69226 -0.31857 -0.09668  0.18354  1.57401
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.94016    0.11298   8.322 1.61e-12 ***
## y0          -0.16878    0.39658  -0.426    0.672
## Hybrid      -0.05751    0.16250  -0.354    0.724
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.425 on 82 degrees of freedom
## Multiple R-squared:  0.003507,   Adjusted R-squared:  -0.0208
## F-statistic: 0.1443 on 2 and 82 DF,  p-value: 0.8659
```

```
summary(lm(y1~y0+On_Premises,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + On_Premises, data = y1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.61120 -0.30057 -0.05893  0.18974  1.64508
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.81158    0.07022  11.558  < 2e-16 ***
## y0          -0.32272    0.37961  -0.850  0.39772
## On_Premises  0.54084    0.17913   3.019  0.00338 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4035 on 82 degrees of freedom
## Multiple R-squared:  0.1018, Adjusted R-squared:  0.07993
## F-statistic: 4.649 on 2 and 82 DF,  p-value: 0.01224
```

```
summary(lm(y1~y0+Online_Only,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Online_Only, data = y1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.58792 -0.31401 -0.06465  0.15753  1.48045
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.97621    0.07193  13.571   <2e-16 ***
## y0          -0.17276    0.38574  -0.448   0.6554
## Online_Only -0.51960    0.24538  -2.118   0.0372 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4142 on 82 degrees of freedom
## Multiple R-squared:  0.05373,    Adjusted R-squared:  0.03065
## F-statistic: 2.328 on 2 and 82 DF,  p-value: 0.1039
```

```
summary(lm(y1~y0+Online_Only+On_Premises,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Online_Only + On_Premises, data = y1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.52827 -0.26693 -0.05372  0.17765  1.58362
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.87304    0.07967  10.958  < 2e-16 ***
```

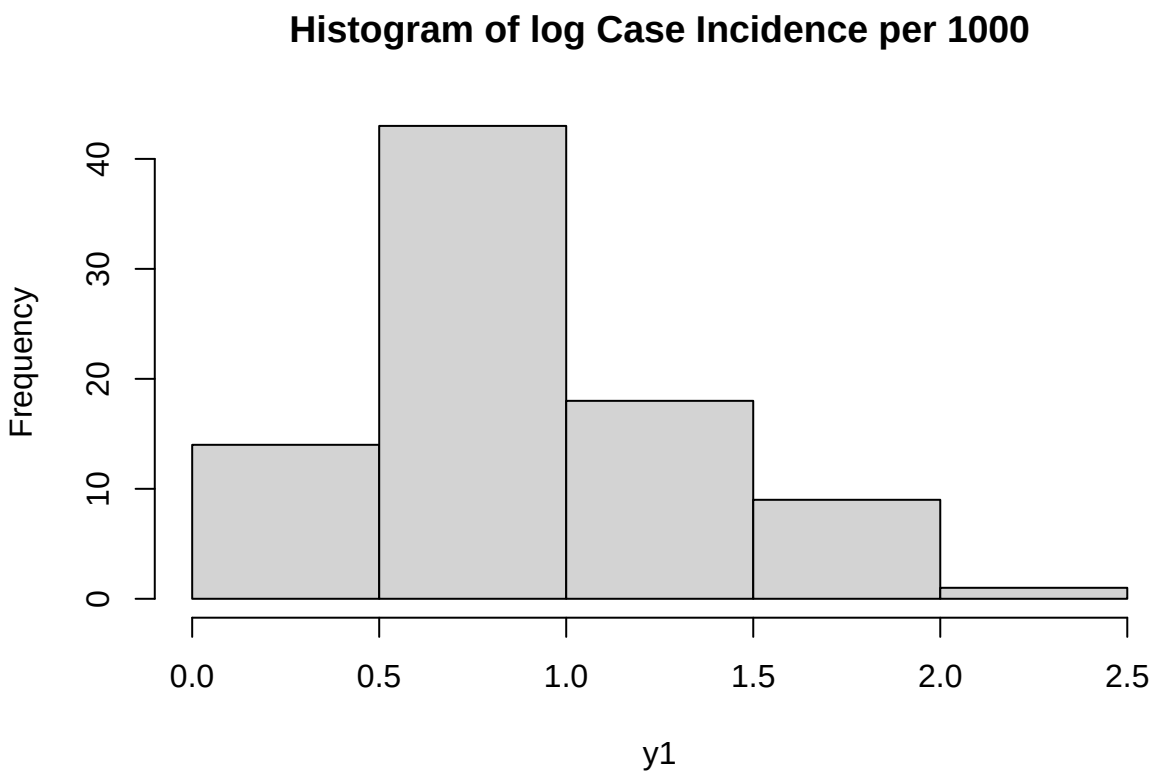
```
## y0          -0.31384    0.37621  -0.834  0.40661
## Online_Only -0.38390    0.24240  -1.584  0.11714
## On_Premises  0.47990    0.18163   2.642  0.00988 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3999 on 81 degrees of freedom
## Multiple R-squared:  0.1288, Adjusted R-squared:  0.09655
## F-statistic: 3.992 on 3 and 81 DF,  p-value: 0.01051
```

```
summary(lm(y1~y0+avg_full_work+On_Premises,data = y1y0))
```

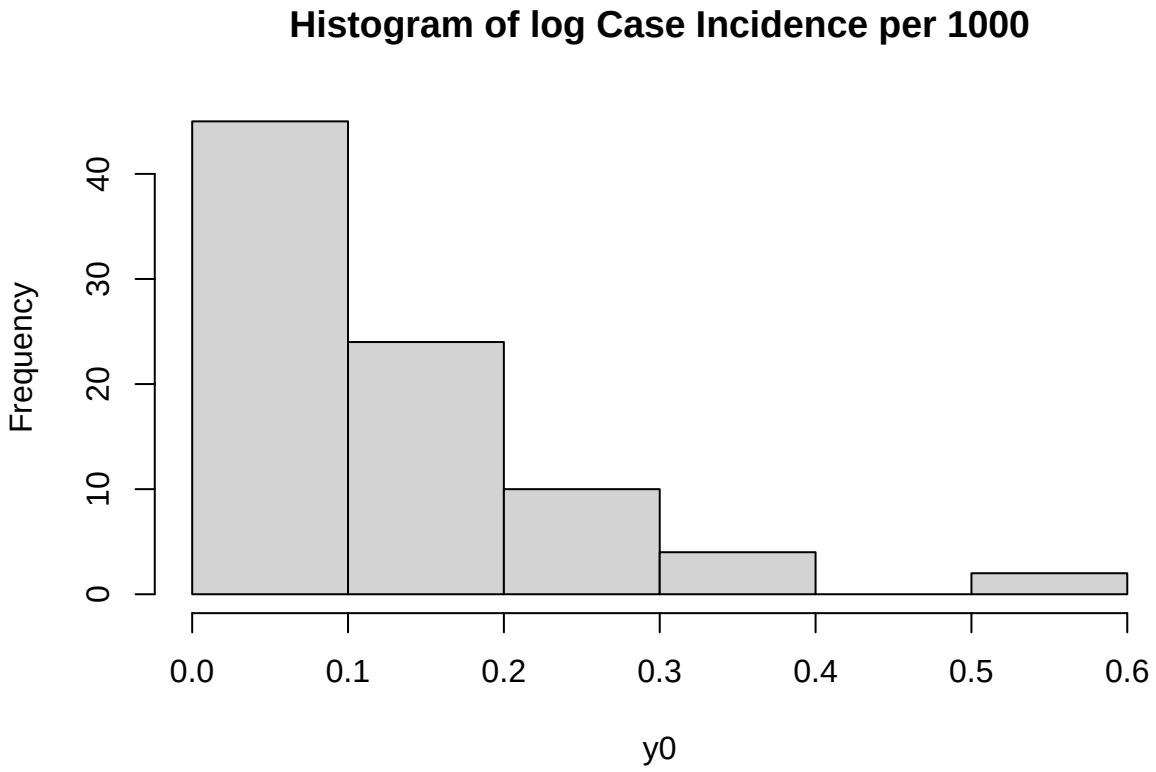
```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work + On_Premises, data = y1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.65300 -0.26872 -0.06464  0.27317  1.14570
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.4105     0.3817  -1.075  0.28544
## y0             -0.6048     0.3696  -1.637  0.10560
## avg_full_work  23.1052     7.1070   3.251  0.00168 **
## On_Premises     0.3097     0.1838   1.685  0.09588 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3819 on 81 degrees of freedom
## Multiple R-squared:  0.2055, Adjusted R-squared:  0.1761
## F-statistic: 6.984 on 3 and 81 DF,  p-value: 0.0003085
```

```
opendate_cases <- case_mobility%>%
  inner_join(major_opendate,by=c('COUNTY'='county'))%>%
  group_by(COUNTY)%>%
  filter(opendategrouped < as.Date("2020-10-15"))%>%
  filter(DATE>=opendategrouped - 14 & DATE<= as.Date('2020-12-25'))%>%
  ungroup()%>%
  mutate(window_id = case_when(
    DATE <= opendategrouped+7 ~"3w_before_1wafteropen",
    opendategrouped+7<DATE & DATE<=opendategrouped+28~"3w_after_1wafteropen",
    TRUE ~ 'Other'))%>%
  mutate(death_per_1000 = round(CUMDEATHS/POPULATION,5)*1000,case_per_1000 = round(CUMCONFIRMED/POPULATI
         window_id = as.factor(window_id))%>%
  left_join(wide_teaching_enroll,by=c('COUNTY'='county','county_enroll'))
# select the start date and end date data for each window of time

incidence_window <- opendate_cases%>%
  group_by(COUNTY,window_id)%>%
  arrange(DATE)%>%
  mutate(avg_full_work = mean(full_work_prop_7d,na.rm = T),avg_part_work =mean(part_work_prop_7d,na.rm =
  filter(row_number()==1 | row_number()==n())%>%
  mutate(incidence = diff(CUMCONFIRMED),incidence_per_1000 = diff(CUMCONFIRMED)*1000/POPULATION)%>%
  distinct(COUNTY,POPULATION,avg_full_work,avg_part_work,avg_res_visit,avg_bar_visit,Online_Only,On_Pre
```

```r
logy1y0 <- incidence_window %>%
  filter(window_id!='Other')%>%
  group_by(COUNTY)%>%
  mutate(y1= log(incidence), y0 = lag(log(incidence),n=1))%>%
  drop_na(y0)

hist(y1y0$y1,main = "Histogram of log Case Incidence per 1000", xlab = "y1")
```




```r
hist(y1y0$y0,main = "Histogram of log Case Incidence per 1000", xlab = "y0")
```




```
summary(lm(y1~y0,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.26160 -0.28646  0.04053  0.30447  2.08514
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.68254    0.23062    2.96  0.00401 **
## y0           0.86099    0.04861   17.71  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5979 on 83 degrees of freedom
## Multiple R-squared:  0.7908, Adjusted R-squared:  0.7882
## F-statistic: 313.7 on 1 and 83 DF,  p-value: < 2.2e-16
```

```
summary(lm(y1~POPULATION,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ POPULATION, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4176 -0.7153  0.0571  0.7798  1.5749
```

```
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 4.050e+00  1.216e-01  33.310  < 2e-16 ***
## POPULATION  4.015e-06  4.678e-07   8.582 4.48e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9514 on 83 degrees of freedom
## Multiple R-squared:  0.4702, Adjusted R-squared:  0.4638
## F-statistic: 73.65 on 1 and 83 DF,  p-value: 4.482e-13
```

```
summary(lm(y1~avg_full_work ,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_full_work, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.8425 -0.8579  0.0083  0.8706  2.7328
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)     7.7600     0.9771   7.941 8.51e-12 ***
## avg_full_work -55.1287    16.8995  -3.262  0.00161 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.23 on 83 degrees of freedom
## Multiple R-squared:  0.1136, Adjusted R-squared:  0.103
## F-statistic: 10.64 on 1 and 83 DF,  p-value: 0.001606
```

```
summary(lm(y1~avg_part_work ,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_part_work, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.7764 -0.9777  0.0692  0.8522  2.3331
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      9.270      1.286   7.207  2.4e-10 ***
## avg_part_work  -51.994     14.252  -3.648  0.00046 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.213 on 83 degrees of freedom
## Multiple R-squared:  0.1382, Adjusted R-squared:  0.1278
## F-statistic: 13.31 on 1 and 83 DF,  p-value: 0.00046
```

```
# correlation unclear
summary(lm(y1~avg_full_work+avg_part_work ,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_full_work + avg_part_work, data = logy1y0,
##     na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.7826 -0.8585  0.0239  0.8264  2.3499
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      9.446      1.291   7.316 1.55e-10 ***
## avg_full_work  -26.590     22.119  -1.202    0.233
## avg_part_work  -36.987     18.918  -1.955    0.054 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.21 on 82 degrees of freedom
## Multiple R-squared:  0.1531, Adjusted R-squared:  0.1325
## F-statistic: 7.413 on 2 and 82 DF,  p-value: 0.001098
```

```
summary(lm(y1~y0+avg_full_work ,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.24612 -0.31688  0.02146  0.29673  2.01136
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.37071    0.65754   0.564    0.574
## y0             0.87196    0.05342  16.323   <2e-16 ***
## avg_full_work  4.57202    9.02251   0.507    0.614
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6006 on 82 degrees of freedom
## Multiple R-squared:  0.7914, Adjusted R-squared:  0.7863
## F-statistic: 155.6 on 2 and 82 DF,  p-value: < 2.2e-16
```

```
summary(lm(y1~y0+avg_part_work ,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_part_work, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.26625 -0.27709  0.05609  0.29306  2.09218
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)    0.85084    0.82663   1.029    0.306
## y0             0.85637    0.05353  15.997   <2e-16 ***
## avg_part_work -1.64029    7.73278  -0.212    0.833
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6013 on 82 degrees of freedom
## Multiple R-squared:  0.7909, Adjusted R-squared:  0.7858
## F-statistic: 155.1 on 2 and 82 DF,  p-value: < 2.2e-16
```

```
summary(lm(y1~y0+avg_res_visit,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_res_visit, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.24884 -0.25681  0.03428  0.29197  2.11463
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.6031448  0.2482894   2.429   0.0174 *
## y0            0.8441026  0.0554916  15.211   <2e-16 ***
## avg_res_visit 0.0004824  0.0003932   1.227   0.2234
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6022 on 80 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.7818, Adjusted R-squared:  0.7763
## F-statistic: 143.3 on 2 and 80 DF,  p-value: < 2.2e-16
```

```
summary(lm(y1~y0+avg_bar_visit,na.action='na.omit',data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_bar_visit, data = logy1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.70595 -0.14091  0.03647  0.16778  0.42959
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -0.358429   0.499398  -0.718    0.484
## y0             1.020021   0.080374  12.691    2e-09 ***
## avg_bar_visit  0.001521   0.001063   1.431    0.173
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3318 on 15 degrees of freedom
##   (67 observations deleted due to missingness)
## Multiple R-squared:  0.9212, Adjusted R-squared:  0.9107
## F-statistic: 87.71 on 2 and 15 DF,  p-value: 5.281e-09
```

```r
summary(lm(y1~y0+Hybrid,data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Hybrid, data = logy1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.25545 -0.28693  0.03895  0.30425  2.09065
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.69277    0.27889   2.484    0.015 *
## y0           0.86058    0.04930  17.455   <2e-16 ***
## Hybrid      -0.01529    0.23135  -0.066    0.947
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6015 on 82 degrees of freedom
## Multiple R-squared:  0.7908, Adjusted R-squared:  0.7857
## F-statistic:   155 on 2 and 82 DF,  p-value: < 2.2e-16
```

```r
summary(lm(y1~y0+On_Premises,data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + On_Premises, data = logy1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.33939 -0.27778  0.06758  0.31669  1.99597
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.77981    0.24591   3.171  0.00214 **
## y0           0.85361    0.04898  17.429  < 2e-16 ***
## On_Premises -0.29816    0.26467  -1.127  0.26321
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5969 on 82 degrees of freedom
## Multiple R-squared:  0.7939, Adjusted R-squared:  0.7889
## F-statistic:   158 on 2 and 82 DF,  p-value: < 2.2e-16
```

```r
summary(lm(y1~y0+Online_Only,data = logy1y0))
```

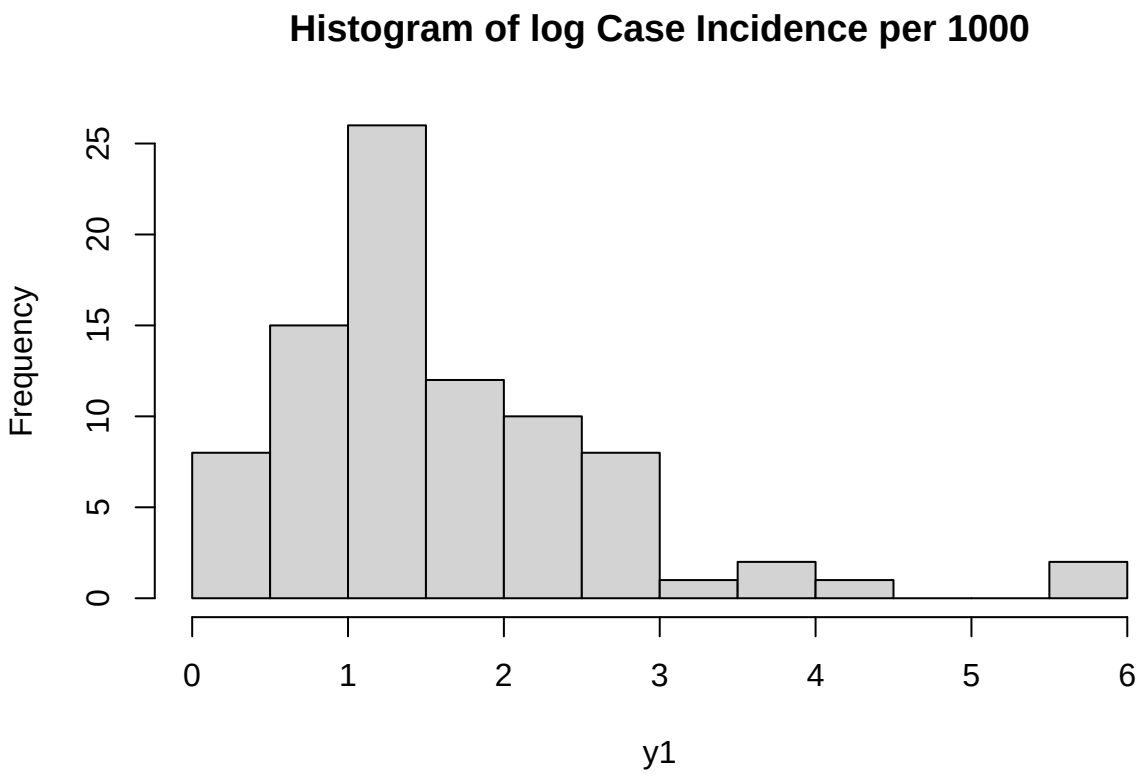
```
##
## Call:
## lm(formula = y1 ~ y0 + Online_Only, data = logy1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.25393 -0.26754  0.09073  0.31124  2.02129
##
## Coefficients:
```

```
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.79738    0.23479   3.396  0.00106 **
## y0           0.81457    0.05364  15.186  < 2e-16 ***
## Online_Only  0.74836    0.39077   1.915  0.05897 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5885 on 82 degrees of freedom
## Multiple R-squared:  0.7997, Adjusted R-squared:  0.7948
## F-statistic: 163.7 on 2 and 82 DF,  p-value: < 2.2e-16
```

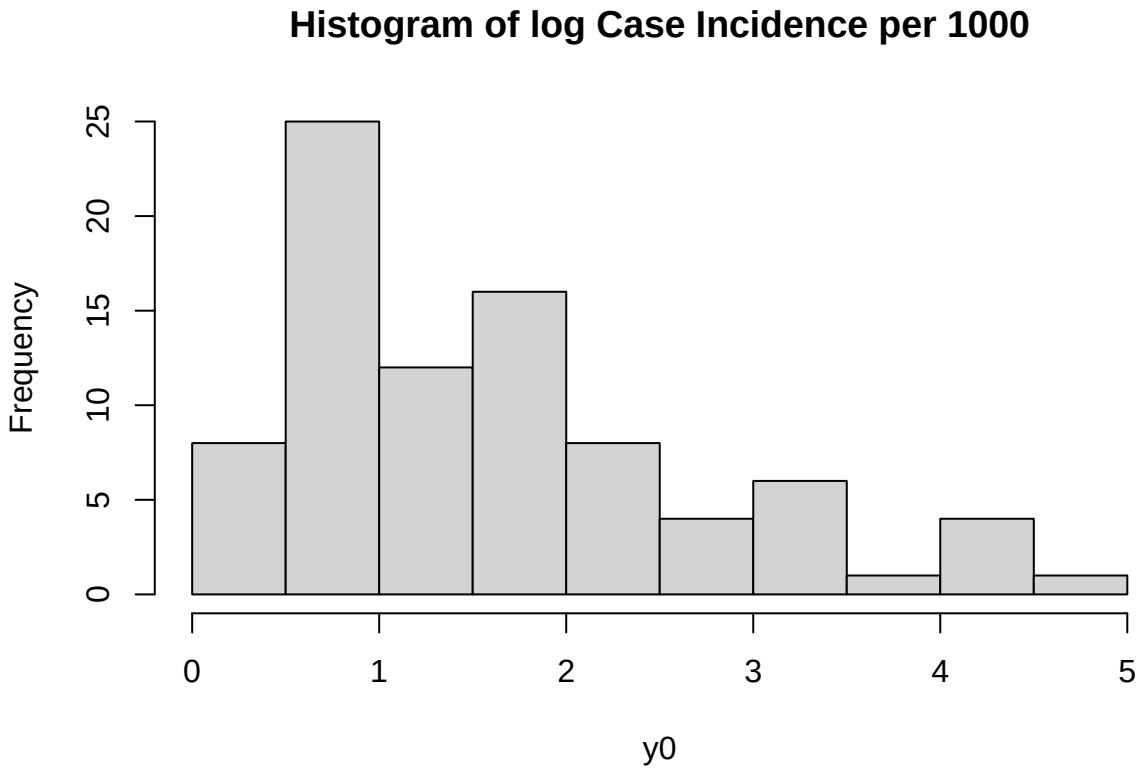
```
summary(lm(y1~y0+Online_Only,data = logy1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Online_Only, data = logy1y0)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.25393 -0.26754  0.09073  0.31124  2.02129
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.79738    0.23479   3.396  0.00106 **
## y0           0.81457    0.05364  15.186  < 2e-16 ***
## Online_Only  0.74836    0.39077   1.915  0.05897 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5885 on 82 degrees of freedom
## Multiple R-squared:  0.7997, Adjusted R-squared:  0.7948
## F-statistic: 163.7 on 2 and 82 DF,  p-value: < 2.2e-16
```

```
y1y0 <- incidence_window %>%
  filter(window_id!='Other')%>%
  group_by(COUNTY)%>%
  mutate(y1= incidence_per_1000, y0 = lag(incidence_per_1000,n=1))%>%
  drop_na(y0)

hist(y1y0$y1,main = "Histogram of log Case Incidence per 1000", xlab = "y1")
```




```
hist(y1y0$y0,main = "Histogram of log Case Incidence per 1000", xlab = "y0")
```




```
summary(lm(y1~y0,na.action='na.omit',data = y1y0))
```

```
##
## Call:
```

```
## lm(formula = y1 ~ y0, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8247 -0.4266 -0.1317  0.3225  3.0214
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.53926    0.15285   3.528 0.000685 ***
## y0           0.68363    0.07847   8.712 2.46e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7905 on 83 degrees of freedom
## Multiple R-squared:  0.4777, Adjusted R-squared:  0.4714
## F-statistic:  75.9 on 1 and 83 DF,  p-value: 2.461e-13
```

```
summary(lm(y1~POPULATION,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ POPULATION, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.4802 -0.7007 -0.3142  0.5474  4.1140
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1.610e+00  1.396e-01  11.526   <2e-16 ***
## POPULATION  2.328e-07  5.372e-07   0.433    0.666
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.093 on 83 degrees of freedom
## Multiple R-squared:  0.002257,   Adjusted R-squared:  -0.009764
## F-statistic: 0.1878 on 1 and 83 DF,  p-value: 0.6659
```

```
summary(lm(y1~avg_full_work ,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ avg_full_work, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.5170 -0.6708 -0.2892  0.5797  4.0065
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)     1.2491     0.8675   1.440    0.154
## avg_full_work   6.8527    15.0038   0.457    0.649
##
## Residual standard error: 1.092 on 83 degrees of freedom
## Multiple R-squared:  0.002507,   Adjusted R-squared:  -0.009511
```

```
## F-statistic: 0.2086 on 1 and 83 DF,  p-value: 0.6491
```

```
summary(lm(y1~y0+avg_full_work ,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8036 -0.4574 -0.1187  0.3384  3.1134
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.15333    0.64265   0.239    0.812
## y0             0.68358    0.07876   8.679 3.13e-13 ***
## avg_full_work  6.73936   10.89795   0.618    0.538
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7935 on 82 degrees of freedom
## Multiple R-squared:  0.4801, Adjusted R-squared:  0.4674
## F-statistic: 37.86 on 2 and 82 DF,  p-value: 2.255e-12
```

```
summary(lm(y1~y0+avg_res_visit,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_res_visit, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.7276 -0.3845 -0.1840  0.3317  2.9872
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.4263907  0.2085708   2.044   0.0442 *
## y0            0.6703237  0.0814511   8.230 2.87e-12 ***
## avg_res_visit 0.0004294  0.0004911   0.874   0.3845
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.801 on 80 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.4749, Adjusted R-squared:  0.4618
## F-statistic: 36.17 on 2 and 80 DF,  p-value: 6.458e-12
```

```
summary(lm(y1~y0+avg_bar_visit,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_bar_visit, data = y1y0, na.action = "na.omit")
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.97078 -0.29654 -0.09272  0.21348  1.08738
```

```
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.702636   0.361041   1.946  0.07062 .
## y0            0.441784   0.142401   3.102  0.00728 **
## avg_bar_visit 0.003039   0.001869   1.626  0.12474
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5913 on 15 degrees of freedom
##   (67 observations deleted due to missingness)
## Multiple R-squared:  0.435,  Adjusted R-squared:  0.3596
## F-statistic: 5.774 on 2 and 15 DF,  p-value: 0.01382
```

```
summary(lm(y1~y0+Hybrid,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Hybrid, data = y1y0)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8274 -0.4233 -0.1357  0.3241  3.0195
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.52347    0.24532   2.134   0.0358 *
## y0           0.68480    0.08019   8.540 5.93e-13 ***
## Hybrid       0.02546    0.30826   0.083   0.9344
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7953 on 82 degrees of freedom
## Multiple R-squared:  0.4777, Adjusted R-squared:  0.465
## F-statistic:  37.5 on 2 and 82 DF,  p-value: 2.72e-12
```

```
summary(lm(y1~y0+On_Premises,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + On_Premises, data = y1y0)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8262 -0.4261 -0.1330  0.3212  3.0199
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.540246   0.160582   3.364  0.00117 **
## y0           0.684039   0.081178   8.426 9.96e-13 ***
## On_Premises -0.007672   0.359374  -0.021  0.98302
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7954 on 82 degrees of freedom
```

```
## Multiple R-squared:  0.4777, Adjusted R-squared:  0.4649
## F-statistic: 37.49 on 2 and 82 DF,  p-value: 2.728e-12
```

```
summary(lm(y1~y0+Online_Only,data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + Online_Only, data = y1y0)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.7407 -0.4410 -0.1152  0.3408  2.9059
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.48873    0.16043   3.046  0.00311 **
## y0           0.67615    0.07877   8.584 4.85e-13 ***
## Online_Only  0.48548    0.47010   1.033  0.30477
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7902 on 82 degrees of freedom
## Multiple R-squared:  0.4844, Adjusted R-squared:  0.4718
## F-statistic: 38.51 on 2 and 82 DF,  p-value: 1.607e-12
```

```
summary(lm(y1~y0+major_teaching,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + major_teaching, data = y1y0, na.action = "na.omit")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8089 -0.4173 -0.1223  0.3325  3.0319
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 0.53063    0.16168   3.282  0.00152 **
## y0                          0.68203    0.08005   8.520 7.07e-13 ***
## major_teachingOn Premises   0.03340    0.23143   0.144  0.88561
## major_teachingOnline Only   0.04116    0.26486   0.155  0.87689
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8001 on 81 degrees of freedom
## Multiple R-squared:  0.4779, Adjusted R-squared:  0.4586
## F-statistic: 24.72 on 3 and 81 DF,  p-value: 1.88e-11
```

```
summary(lm(y1~y0+avg_full_work+On_Premises,na.action='na.omit',data = y1y0))
```

```
##
## Call:
## lm(formula = y1 ~ y0 + avg_full_work + On_Premises, data = y1y0,
##     na.action = "na.omit")
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -1.8102 -0.4441 -0.1211  0.3325  3.1084
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.15020    0.64735   0.232    0.817
## y0             0.68546    0.08152   8.409 1.17e-12 ***
## avg_full_work  6.87437   11.04992   0.622    0.536
## On_Premises   -0.03576    0.36354  -0.098    0.922
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7983 on 81 degrees of freedom
## Multiple R-squared:  0.4801, Adjusted R-squared:  0.4609
## F-statistic: 24.94 on 3 and 81 DF,  p-value: 1.583e-11
```