

# Mental Health Series

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## Base Panel Construction - ZCTA-Week Level

### Hospital Data - ZCTA-Week level

```
hosp_zcta <- read_csv("Data/Restricted MHA Data/minnepop_1620_agg_zipfull_MH_102222.csv") %>%  
  arrange(zipcode, year, weekofyr) %>%  
  select(-c(`_chk`, zippop_tag)) %>%  
  filter(!(year==2016 & weekofyr==53))
```

### ZCTAs and ACS 5-Year Estimates

```
#adding in 5-year ACS data  
census_api_key("ecda17575f4d914b502c70f2bae7a5f3d253792d")  
  
year <- lst(2016, 2017, 2018, 2019, 2020)  
  
acs <- map_dfr(  
  year,  
  ~ get_acs(geography = "zcta",  
            variables = c("B01001_001E", "B03003_003E",  
                          "B02001_003E", "B02001_002E",  
                          "B02001_004E", "B02001_008E",  
                          "B02001_005E", "B02001_006E",  
                          "B02001_007E", "B11001_003E",  
                          "B17001_002E", "B01002_001E",  
                          "B09010_002E", "B06009_005E",  
                          "B01001_002E", "B99233_005E"),  
            output = "wide",  
            survey = "acs5",  
            year = .x), .id = "year") %>%  
  rename(total_pop = B01001_001E,  
         white_pop = B02001_002E,  
         black_pop = B02001_003E,  
         na_pop = B02001_004E,  
         asian_pop = B02001_005E,  
         hpi_pop = B02001_006E,  
         other_pop = B02001_007E,  
         biracial_pop = B02001_008E,  
         hisp_pop = B03003_003E,  
         ssi_snap = B09010_002E, #snap, ssi, public cash transfers  
         med_age = B01002_001E,
```

```

    mar_fam = B11001_003E,
    povlevel = B17001_002E,
    bach_degree = B06009_005E,
    male = B01001_002E,
    nowork_12 = B99233_005E) %>%
select(-ends_with("M", ignore.case = F), -GEOID) %>%
mutate(zcta = str_sub(NAME, 6)) %>%
select(-NAME) %>%
select(zcta, everything()) %>%
mutate(year = as.numeric(year),
       zcta = as.numeric(zcta))

```

*#joining to hospital data*

```

hosp_panel <- hosp_zcta %>%
  left_join(acs, by = c("zipcode"="zcta", "year"))

```

*#SF geometries - get all ZCTAs*

```

zcta <- get_acs(geography = "zcta",
               variables = "B01001_001",
               output = "wide",
               year = 2020,
               geometry = T,
               survey = "acs5") %>%
  rename(zcta = GEOID,
         pop_2019 = B01001_001E) %>%
  select(-c(NAME, B01001_001M, pop_2019)) %>%
  mutate(zcta = as.numeric(zcta))

```

```
## |
```

*#minneapolis shapefile (source: openminneapolis.gov)*

```

mpls <- st_read("Data/mpls_city-shp/16cdbbfa-ad10-493c-afaf-52b61f2e76e42020329-1-180h9ap.whbo.shp") %>%
  st_set_crs(st_crs(zcta))

```

```

## Reading layer `16cdbbfa-ad10-493c-afaf-52b61f2e76e42020329-1-180h9ap.whbo' from data source `C:\User
## using driver `ESRI Shapefile'
## Simple feature collection with 1 feature and 4 fields
## Geometry type: POLYGON
## Dimension: XY
## Bounding box: xmin: -93.32911 ymin: 44.89059 xmax: -93.19433 ymax: 45.05125
## Geodetic CRS: WGS 84

```

*#zctas that intersect MPLS*

```

zcta_intersect <- zcta %>%
  st_filter(mpls, .predicate = st_intersects) %>%
  mutate(zcta_area = as.numeric(st_area(.)),
         zcta_area_sqkm = zcta_area*.000001,
         zcta_area_sqmi = zcta_area_sqkm*.386102,
         intersection_area = as.numeric(st_area(st_intersection(., mpls))),
         perc_intersection = round(intersection_area/zcta_area*100,2)) %>%
  filter(perc_intersection >= 5)

```

*#filter hospital panel*

```

panel <- hosp_panel %>%
  filter(zipcode %in% zcta_intersect$zcta) %>%

```

```

mutate(zcta = zipcode)

#creating date bookends
panel <- panel %>%
  group_by(zipcode, year) %>%
  mutate(begin_date = ISOweek2date(paste(year, paste0("W", sprintf("%02d", weekofyr)), 1, sep = "-")),
         end_date = begin_date+weeks(1)-days(1))

#number of unique MPLS ZCTAs
n_zcta <- length(unique(panel$zcta))

#vector of intersecting ZCTAs for filtering downstream
zcta_universe <- unique(panel$zcta)

```

## ZCTA-Week Level Police Data

```

#Minneapolis Police Department - Use of Force Dashboard
uof_spatial <- read_csv("Data/Police_Use_Of_Force.csv") %>%
  mutate(date=ymd_hms(ResponseDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  select(OBJECTID, year, week, X, Y, Race) %>%
  st_as_sf(coords = c("X", "Y"), crs = "NAD83", remove=F) %>%
  mutate(intersection = as.integer(st_intersects(geometry, zcta)),
         zcta = ifelse(is.na(intersection), NA, zcta$zcta[intersection])) %>%
  st_drop_geometry() %>%
  filter(!is.na(zcta) & year >= 2016 & year <= 2021 & zcta %in% zcta_universe) %>%
  group_by(year, week, zcta, Race, .drop=F) %>%
  tally(name = "use_of_force") %>%
  filter(!is.na(Race) & Race!="not recorded") %>%
  ungroup() %>%
  complete(year, week, zcta=zcta_universe, Race, fill = list(use_of_force = 0)) %>%
  arrange(year, week, zcta, Race) %>%
  mutate(race = str_to_lower(Race)) %>%
  select(-Race) %>%
  pivot_wider(names_from = race,
             values_from = use_of_force,
             values_fill = 0,
             names_glue = "{race}_{.value}") %>%
  mutate(total_use_of_force = asian_use_of_force+black_use_of_force+`native american_use_of_force`+
         `other / mixed race_use_of_force`+`pacific islander_use_of_force`+unknown_use_of_force+
         white_use_of_force)

#MPD Stop Dashboard
stop_spatial <- read_csv("Data/Police_Stop_Data.csv") %>%
  mutate(date=ymd_hms(responseDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  select(OBJECTID, year, week, lat, long, race) %>%
  st_as_sf(coords = c("long", "lat"), crs = "NAD83", remove=F) %>%
  mutate(intersection = as.integer(st_intersects(geometry, zcta)),
         zcta = ifelse(is.na(intersection), NA, zcta$zcta[intersection])) %>%
  st_drop_geometry() %>%

```

```

filter(!is.na(zcta) & year >= 2016 & year <= 2020 & zcta %in% zcta_universe) %>%
group_by(year, week, zcta, race, .drop=F) %>%
tally(name = "police_stops") %>%
  filter(!is.na(race) & race!="not recorded") %>%
ungroup() %>%
complete(year, week, zcta=zcta_universe, race, fill = list(police_stops = 0)) %>%
mutate(race = str_to_lower(race)) %>%
arrange(year, week, zcta, race) %>%
pivot_wider(names_from = race,
             values_from = police_stops,
             values_fill = 0,
             names_glue = "{race}_{.value}") %>%
mutate(total_police_stops = asian_police_stops+black_police_stops+
  `east african_police_stops`+latino_police_stops+`native american_police_stops`+
  other_police_stops+unknown_police_stops+white_police_stops)

#Officer Involved Shootings - MPD
ois_spatial <- read_csv("Data/Police_Officer_Involved_Shootings.csv") %>%
  mutate(date=ymd_hms(IncidentDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  select(OBJECTID, year, week, CenterLatitude, CenterLongitude, SubjectOfForceRace) %>%
  rename(race = SubjectOfForceRace,
         lat = CenterLatitude,
         long = CenterLongitude) %>%
  st_as_sf(coords = c("long", "lat"), crs = "NAD83", remove=F) %>%
  mutate(intersection = as.integer(st_intersects(geometry, zcta)),
         zcta = ifelse(is.na(intersection), NA, zcta$zcta[intersection])) %>%
  st_drop_geometry() %>%
  filter(!is.na(zcta) & year >= 2016 & year <= 2020 & zcta %in% zcta_universe) %>%
  group_by(year, week, zcta, race, .drop=F) %>%
  tally(name = "police_shootings") %>%
  filter(!is.na(race) & race!="not recorded") %>%
  ungroup() %>%
  complete(year=2016:2021, week=1:53, zcta=zcta_universe, race, fill = list(police_shootings = 0)) %>%
  mutate(race = str_to_lower(race)) %>%
  arrange(year, week, zcta, race) %>%
  pivot_wider(names_from = race,
             values_from = police_shootings,
             values_fill = 0,
             names_glue = "{race}_{.value}") %>%
  mutate(total_police_shootings = asian_police_shootings+black_police_shootings+
    hispanic_police_shootings+other_police_shootings+
    unknown_police_shootings+white_police_shootings)

panel <- panel %>%
  left_join(uof_spatial, by = c("year", "weekofyr"="week", "zcta"="zcta")) %>%
  left_join(stop_spatial, by = c("year", "weekofyr"="week", "zcta"="zcta")) %>%
  left_join(ois_spatial, by = c("year", "weekofyr"="week", "zcta"="zcta"))

#creating period indicators for panel
panel <- panel %>%
  mutate(post_floyd = as.numeric(begin_date >= as.Date("2020-05-25")),

```

```

post_floyd_3 = as.numeric(begin_date >= as.Date("2020-05-25")+months(3)),
t_post_floyd = ifelse(as.numeric(as.Date("2020-05-25")-begin_date)/7 >=0,
                      as.numeric(as.Date("2020-05-25")-begin_date)/7,
                      0),
stay_at_home = as.numeric(begin_date >= as.Date("2020-03-28") &
state_of_emerg = as.numeric(begin_date >= as.Date("2020-03-13")),
period = factor(case_when(
  post_floyd==0 & post_floyd_3==0 ~ "Pre-Killing",
  post_floyd>=1 & post_floyd_3==0 ~ "0-3 Months Post-Killing",
  post_floyd>=1 & post_floyd_3>=1 ~ "3+ Months Post-Killing"),
  levels = c("Pre-Killing", "0-3 Months Post-Killing", "3+ Months Post-Killing")) %>%
group_by(zcta) %>%
arrange(year, weekofyr) %>%
mutate(t = row_number(),
       uof_lag = dplyr::lag(total_use_of_force, 1),
       stops_lag = dplyr::lag(total_police_stops, 1),
       shoot_lag = dplyr::lag(total_police_shootings, 1))

```

## Weather Data

```

# Minnesota DNR Daily Date
# https://www.dnr.state.mn.us/climate/historical/daily-data.html?sid=mspthr&sname=Minneapolis/St%20Paul
# Station Name: Minneapolis/St Paul Threaded Record - Station ID: mspthr

weather <- read_csv("Data/dnr_weather.csv") %>%
  mutate(year=isoyear(Date),
         week=isoweek(Date),
         precip_in = as.numeric(ifelse(`Precipitation (inches)`=="T", .001, `Precipitation (inches)`)),
         snow_in = as.numeric(ifelse(`Snow (inches)`=="T", .001, `Snow (inches)`)),
         tmax_f = `Maximum Temperature degrees (F)` %>%
filter(year >= 2016 & year <= 2020) %>%
select(year, week, precip_in, snow_in, tmax_f) %>%
group_by(year, week) %>%
summarize(precip_in = mean(precip_in, na.rm = T),
          snow_in = mean(snow_in, na.rm = T),
          tmax_f = mean(tmax_f, na.rm = T))

#join to panel
panel <- panel %>% left_join(weather, by = c("year", "weekofyr"="week"))

```

## Time Series Construction - Week Level

### Aggregate Hospital Panel to Week-Level

```

#panel to week-level, aggregating over ZCTAs
hosp_series <- panel %>%
  group_by(year, weekofyr) %>%
  summarize(mh_all_tot = sum(mh_all_tot, na.rm = T),
           white_mh_all_tot = sum(white_mh_all_tot, na.rm = T),
           indig_mh_all_tot = sum(indig_mh_all_tot, na.rm = T),
           asian_mh_all_tot = sum(asian_mh_all_tot, na.rm = T),

```

```

    black_mh_all_tot = sum(black_mh_all_tot, na.rm = T),
    latin_mh_all_tot = sum(latin_mh_all_tot, na.rm = T),
    total_pop = sum(total_pop, na.rm = T),
    white_pop = sum(white_pop, na.rm = T),
    na_pop = sum(na_pop, na.rm = T),
    hisp_pop = sum(hisp_pop, na.rm = T),
    asian_pop = sum(asian_pop, na.rm = T),
    black_pop = sum(black_pop, na.rm = T)) %>%
mutate(mh_incid_c = (mh_all_tot/total_pop)*1000,
       white_mh_incid_c = (white_mh_all_tot/white_pop)*1000,
       indig_mh_incid_c = (indig_mh_all_tot/na_pop)*1000,
       asian_mh_incid_c = (asian_mh_all_tot/asian_pop)*1000,
       black_mh_incid_c = (black_mh_all_tot/black_pop)*1000,
       latin_mh_incid_c = (latin_mh_all_tot/hisp_pop)*1000) %>%
ungroup() %>%
mutate(week_id = row_number())

```

## Police Data Week-Level

```

#Minneapolis Police Department - Use of Force Dashboard
uof <- read_csv("Data/Police_Use_Of_Force.csv") %>%
  mutate(date=ymd_hms(ResponseDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  group_by(year, week, .drop=F) %>%
  tally(name = "use_of_force") %>%
  arrange(year, week) %>%
  ungroup() %>%
  select(year, week, everything())

#merge onto series
series <- hosp_series %>%
  left_join(uof, by=c("year", "weekofyr"="week")) %>%
  mutate(use_of_force_rate = (use_of_force/total_pop)*1000)

#MPD Officer Involved Shootings
ois <- read_csv("Data/Police_Officer_Involved_Shootings.csv") %>%
  mutate(date=ymd_hms(IncidentDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  group_by(year, week, .drop=F) %>%
  tally(name = "off_inv_shooting") %>%
  arrange(year, week) %>%
  ungroup() %>%
  select(year, week, everything())

#merge onto series
series <- series %>%
  left_join(ois, by=c("year", "weekofyr"="week")) %>%
  mutate(off_inv_shooting = ifelse(is.na(off_inv_shooting), 0, off_inv_shooting),
         off_inv_shooting_rate = (off_inv_shooting/total_pop)*1000)

```

```

#Minneapolis Police Department - Police Stops Dashboard
stop <- read_csv("Data/Police_Stop_Data.csv") %>%
  mutate(date=ymd_hms(responseDate),
         year=isoyear(date),
         week=isoweek(date)) %>%
  group_by(year, week, .drop=F) %>%
  tally(name = "police_stops")

#merge onto series
series <- series %>%
  left_join(stop, by = c("year", "weekofyr"="week")) %>%
  mutate(police_stop_rate = (police_stops/total_pop)*1000)

#creating date variable
#removing week 53 of 2020

series <- series %>%
  mutate(begin_date = ISOweek2date(paste(year, paste0("W", sprintf("%02d", weekofyr)), 1, sep = "-")),
         end_date = begin_date+weeks(1)-days(1)) %>%
  filter(!(year==2020 & weekofyr== 53)) %>%
  left_join(weather, by = c("year", "weekofyr"="week"))

```

## Time Series Vizualization

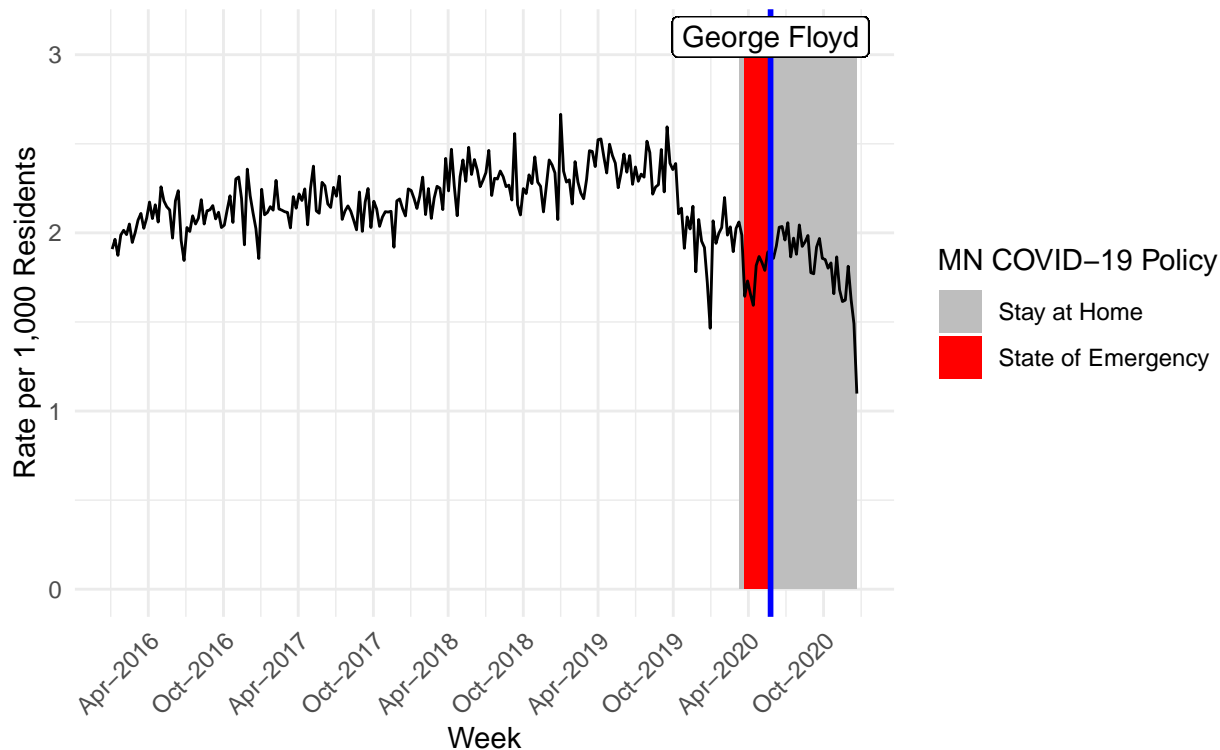
```

ggplot(series)+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-13"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-12-25"))],
    ymin = 0,
    ymax = 3,
    fill = "State of Emergency"
  )) +
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-28"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-18"))],
    ymin = 0,
    ymax = 3,
    fill = "Stay at Home"
  )) +
  scale_fill_manual(values=c("grey","red"), labels=c("Stay at Home", "State of Emergency")) +
  geom_line(aes(x=begin_date, y=mh_incid_c))+
  geom_vline(xintercept=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
            linetype="solid", color="blue", size=1) +
  geom_label(aes(x=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
                y=3.1),
            label = "George Floyd", show.legend = FALSE)+
  labs(title = "Figure 1: Weekly Mental Health Discharges, 2016-2020",
       subtitle = "MHA Hospital Data",
       x = "Week",
       y = "Rate per 1,000 Residents",
       fill = "MN COVID-19 Policy")+

```

```
theme_minimal()+
  theme(axis.text.x=element_text(angle=45, hjust=1))
```

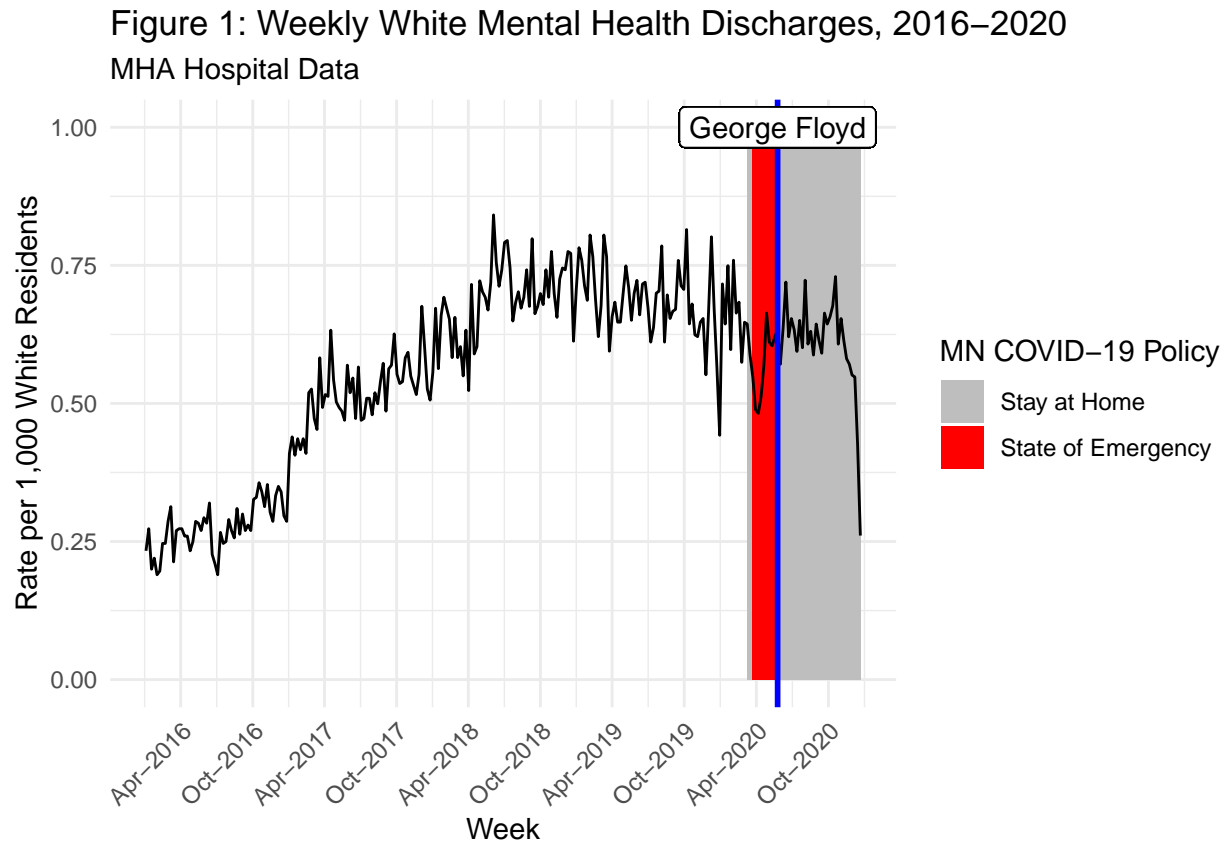
Figure 1: Weekly Mental Health Discharges, 2016–2020  
MHA Hospital Data



```
ggplot(series)+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-13"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-12-25"))],
    ymin = 0,
    ymax = 1,
    fill = "State of Emergency"
  )) +
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-28"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-18"))],
    ymin = 0,
    ymax = 1,
    fill = "Stay at Home"
  )) +
  scale_fill_manual(values=c("grey","red"), labels=c("Stay at Home", "State of Emergency")) +
  geom_line(aes(x=begin_date, y=white_mh_incid_c))+
  geom_vline(xintercept=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
    linetype="solid", color="blue", size=1) +
  geom_label(aes(x=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
    y=1),
    label = "George Floyd", show.legend = FALSE)+
```



```
labs(title = "Figure 1: Weekly White Mental Health Discharges, 2016–2020",
     subtitle = "MHA Hospital Data",
     x = "Week",
     y = "Rate per 1,000 White Residents",
     fill = "MN COVID-19 Policy")+
theme_minimal()+
  theme(axis.text.x=element_text(angle=45, hjust=1))
```



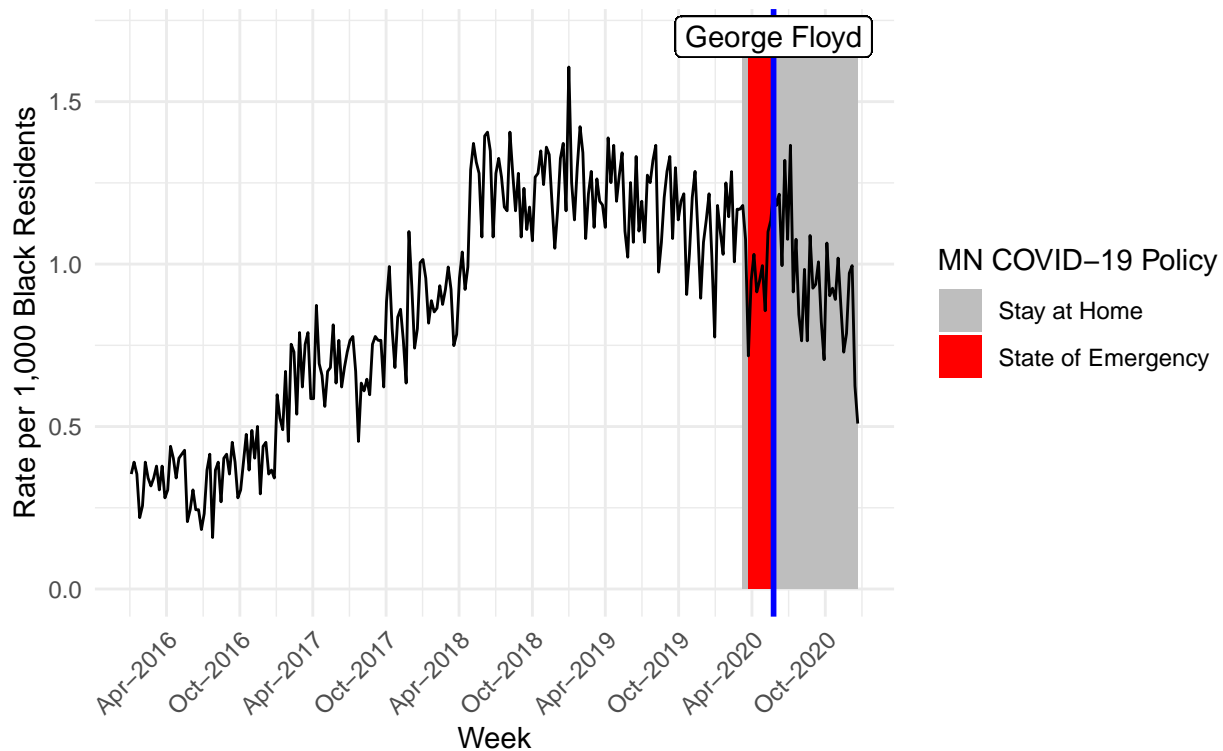
```
ggplot(series)+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-13"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-12-25"))],
    ymin = 0,
    ymax = 1.7,
    fill = "State of Emergency"
  )) +
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-28"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-18"))],
    ymin = 0,
    ymax = 1.7,
    fill = "Stay at Home"
  )) +
  scale_fill_manual(values=c("grey","red"), labels=c("Stay at Home", "State of Emergency")) +
  geom_line(aes(x=begin_date, y=black_mh_incid_c))+
```

```

geom_vline(xintercept=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
           linetype="solid", color="blue", size=1) +
geom_label(aes(x=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
              y=1.7),
           label = "George Floyd", show.legend = FALSE)+
labs(title = "Figure 1: Weekly Black Mental Health Discharges, 2016-2020",
     subtitle = "MHA Hospital Data",
     x = "Week",
     y = "Rate per 1,000 Black Residents",
     fill = "MN COVID-19 Policy")+
theme_minimal()+
  theme(axis.text.x=element_text(angle=45, hjust=1))

```

Figure 1: Weekly Black Mental Health Discharges, 2016–2020  
MHA Hospital Data



```

ggplot(series)+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-13"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-12-25"))],
    ymin = 0,
    ymax = 1.25,
    fill = "State of Emergency"
  )) +
  geom_rect(aes(
    xmin = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-03-28"))],
    xmax = series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-18"))],
    ymin = 0,

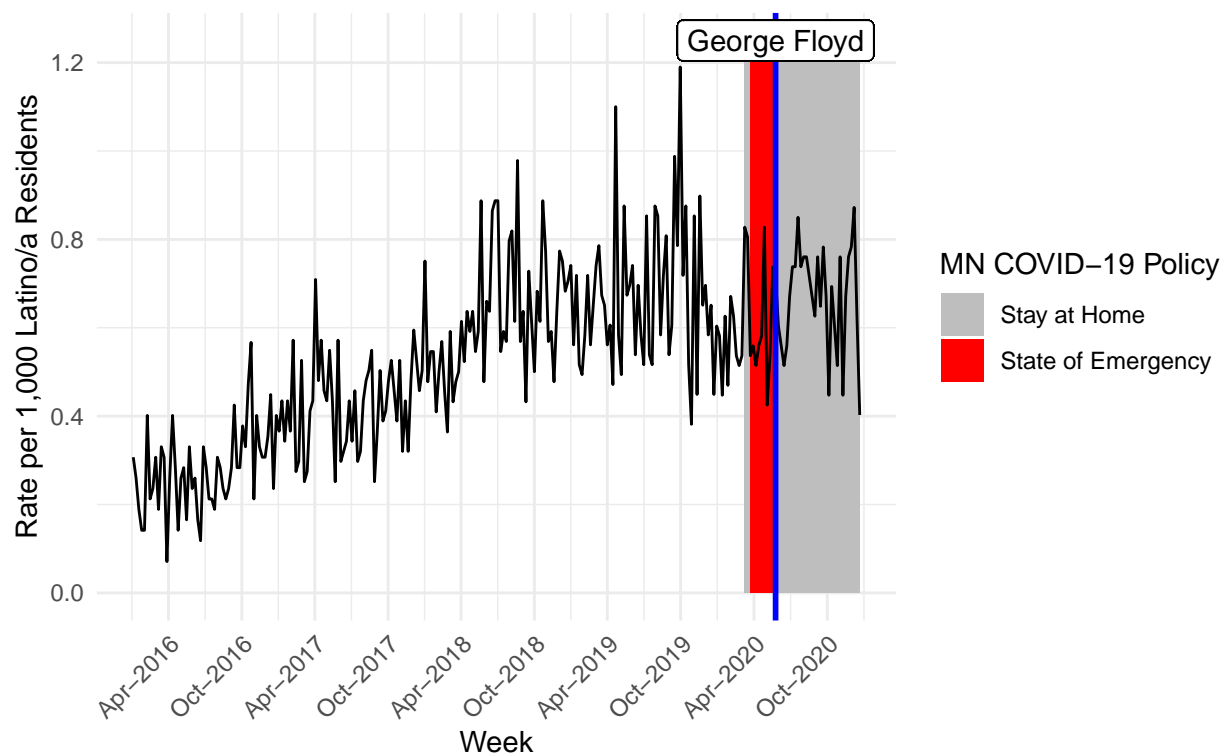
```

```

    ymax = 1.25,
    fill = "Stay at Home"
  )) +
  scale_fill_manual(values=c("grey", "red"), labels=c("Stay at Home", "State of Emergency")) +
  geom_line(aes(x=begin_date, y=latin_mh_incid_c)) +
  geom_vline(xintercept=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
    linetype="solid", color="blue", size=1) +
  geom_label(aes(x=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
    y=1.25),
    label = "George Floyd", show.legend = FALSE) +
  labs(title = "Figure 1: Weekly Latino/a Mental Health Discharges, 2016-2020",
    subtitle = "MHA Hospital Data",
    x = "Week",
    y = "Rate per 1,000 Latino/a Residents",
    fill = "MN COVID-19 Policy") +
  theme_minimal() +
  theme(axis.text.x=element_text(angle=45, hjust=1))

```

Figure 1: Weekly Latino/a Mental Health Discharges, 2016–2020  
MHA Hospital Data



## Time Series Analysis

```

series <- series %>%
  mutate(t = 1:length(mh_incid_c),
    post_floyd = as.factor(as.numeric(begin_date >= as.Date("2020-05-25"))),
    post_floyd_3 = as.factor(as.numeric(begin_date >= as.Date("2020-05-25")+months(3))),
    stay_at_home = as.factor(as.numeric(begin_date >= as.Date("2020-03-28") &

```

```

state_of_emerg = as.factor(as.numeric(begin_date >= as.Date("2020-03-13"))),
t_post_floyd = ifelse(as.numeric(as.Date("2020-05-25")-begin_date)/7 >= 0,
                      as.numeric(as.Date("2020-05-25")-begin_date)/7,
                      0),
uof_lag=lag(use_of_force_rate,1),
stops_lag = lag(police_stop_rate,1),
shoot_lag = lag(off_inv_shooting_rate,1))

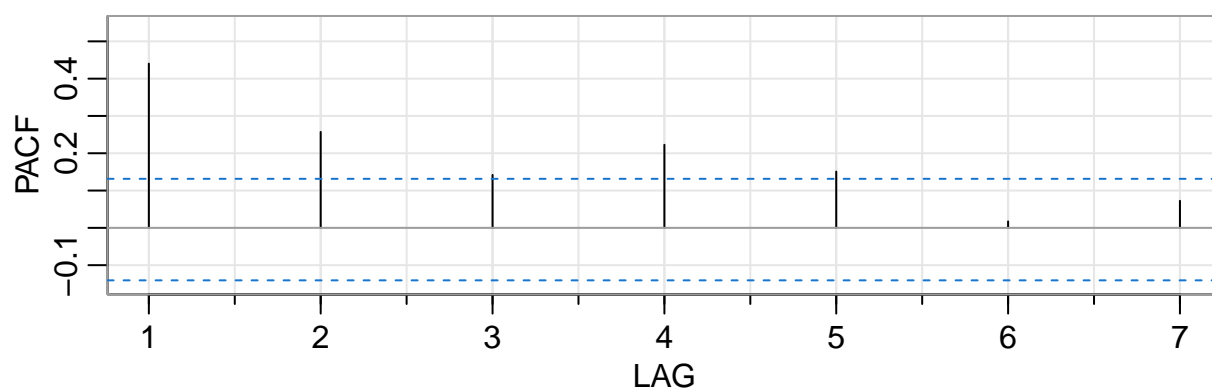
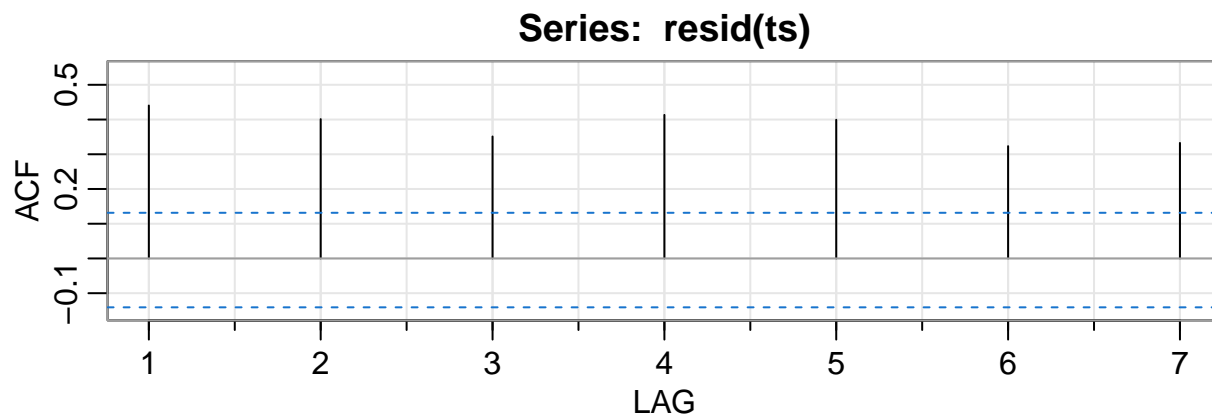
ts <- lm(mh_incid_c~t+state_of_emerg+stay_at_home+post_floyd+t_post_floyd+
        tmax_f+snow_in+precip_in+
        uof_lag+stops_lag+shoot_lag,
        data = series)

summary(ts)

##
## Call:
## lm(formula = mh_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + t_post_floyd + tmax_f + snow_in + precip_in +
##     uof_lag + stops_lag + shoot_lag, data = series)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.74151 -0.06959 -0.00027  0.08705  0.49370
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5.255e+00  7.995e-01   6.573 4.05e-10 ***
## t             -1.366e-02  3.475e-03  -3.931 0.000116 ***
## state_of_emerg1 -3.895e-01  9.404e-02  -4.142 5.05e-05 ***
## stay_at_home1  -9.748e-02  9.707e-02  -1.004 0.316456
## post_floyd1     9.962e-02  1.018e-01   0.978 0.329139
## t_post_floyd   -1.377e-02  3.505e-03  -3.928 0.000117 ***
## tmax_f          3.226e-03  6.541e-04   4.931 1.69e-06 ***
## snow_in         2.271e-02  2.842e-02   0.799 0.425180
## precip_in      -1.316e-01  9.978e-02  -1.319 0.188612
## uof_lag         3.674e-01  2.248e-01   1.634 0.103788
## stops_lag      -4.011e-02  3.728e-02  -1.076 0.283296
## shoot_lag      -1.348e+01  6.536e+00  -2.062 0.040472 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1514 on 204 degrees of freedom
## (44 observations deleted due to missingness)
## Multiple R-squared:  0.5965, Adjusted R-squared:  0.5747
## F-statistic: 27.42 on 11 and 204 DF,  p-value: < 2.2e-16

acf2(resid(ts), max.lag = 7)

```

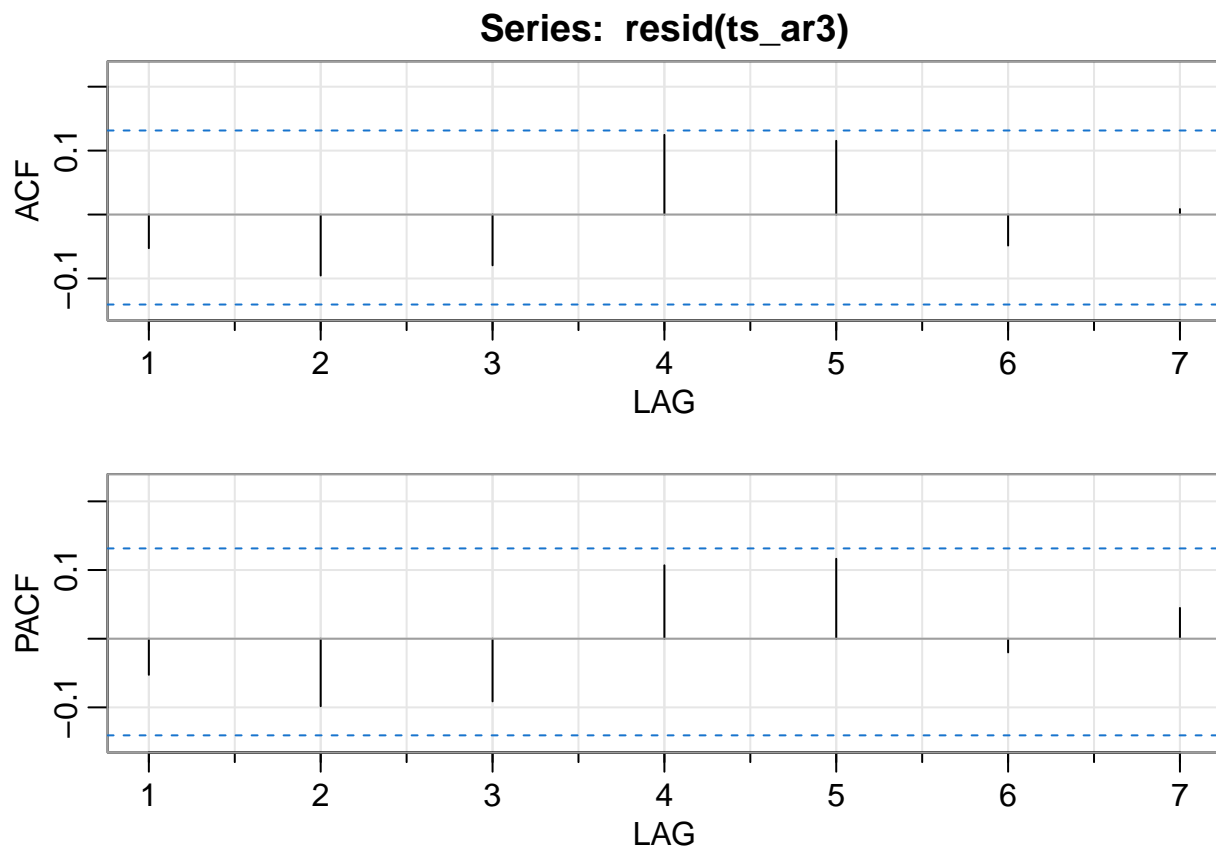


```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7]
## ACF  0.44 0.40 0.35 0.41 0.40 0.32 0.33
## PACF 0.44 0.26 0.14 0.22 0.15 0.02 0.07
```

```
ts_ar3<- lm(mh_incid_c~t+state_of_emerg+stay_at_home+post_floyd+t_post_floyd+
            uof_lag+stops_lag+shoot_lag+
            tmax_f+snow_in+precip_in+
            dplyr::lag(mh_incid_c, 1)+ dplyr::lag(mh_incid_c, 2)+
            dplyr::lag(mh_incid_c, 3),
            data = series)
summary(ts_ar3)
```

```
##
## Call:
## lm(formula = mh_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + t_post_floyd + uof_lag + stops_lag + shoot_lag +
##     tmax_f + snow_in + precip_in + dplyr::lag(mh_incid_c, 1) +
##     dplyr::lag(mh_incid_c, 2) + dplyr::lag(mh_incid_c, 3), data = series)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.47466 -0.07480  0.00068  0.06902  0.45274
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2.823e+00  7.132e-01   3.958 0.000105 ***
## t             -9.743e-03  2.938e-03  -3.317 0.001082 **
```

```
## state_of_emerg1      -1.982e-01  8.105e-02  -2.445  0.015335 *
## stay_at_home1       6.603e-02  8.258e-02   0.800  0.424862
## post_floyd1         1.521e-01  8.520e-02   1.785  0.075803 .
## t_post_floyd        -9.658e-03  2.966e-03  -3.256  0.001325 **
## uof_lag             4.116e-01  1.884e-01   2.185  0.030036 *
## stops_lag          -3.021e-02  3.118e-02  -0.969  0.333756
## shoot_lag          -1.114e+01  5.470e+00  -2.036  0.043053 *
## tmax_f             1.522e-03  5.766e-04   2.640  0.008951 **
## snow_in            1.109e-02  2.379e-02   0.466  0.641547
## precip_in          -2.594e-01  8.433e-02  -3.076  0.002389 **
## dplyr::lag(mh_incid_c, 1) 3.154e-01  6.905e-02   4.567  8.6e-06 ***
## dplyr::lag(mh_incid_c, 2) 2.679e-01  6.944e-02   3.859  0.000154 ***
## dplyr::lag(mh_incid_c, 3) 1.350e-01  6.843e-02   1.973  0.049870 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.126 on 201 degrees of freedom
## (44 observations deleted due to missingness)
## Multiple R-squared:  0.7247, Adjusted R-squared:  0.7055
## F-statistic: 37.8 on 14 and 201 DF, p-value: < 2.2e-16
acf2(resid(ts_ar3), max.lag = 7)
```



```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7]
## ACF  -0.05 -0.1 -0.08 0.12 0.12 -0.05 0.01
## PACF  -0.05 -0.1 -0.09 0.11 0.12 -0.02 0.04
```

```

#race specific models

ts_ar3_white <- lm(white_mh_incid_c~t+state_of_emerg+stay_at_home+post_floyd+t_post_floyd+
                  uof_lag+stops_lag+shoot_lag+
                  tmax_f+snow_in+precip_in+
                  dplyr::lag(white_mh_incid_c, 1)+ dplyr::lag(white_mh_incid_c, 2)+
                  dplyr::lag(white_mh_incid_c, 3),
                  data = series)
summary(ts_ar3_white)

##
## Call:
## lm(formula = white_mh_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + t_post_floyd + uof_lag + stops_lag + shoot_lag +
##     tmax_f + snow_in + precip_in + dplyr::lag(white_mh_incid_c,
##     1) + dplyr::lag(white_mh_incid_c, 2) + dplyr::lag(white_mh_incid_c,
##     3), data = series)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.205278 -0.034589 -0.002865  0.038491  0.161720
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.1112187   0.3344785   3.322  0.00106 **
## t             -0.0042313   0.0014438  -2.931  0.00377 **
## state_of_emerg1 -0.0570246   0.0404216  -1.411  0.15987
## stay_at_home1   0.0159212   0.0405788   0.392  0.69521
## post_floyd1     0.0610518   0.0422839   1.444  0.15034
## t_post_floyd   -0.0045808   0.0014591  -3.140  0.00195 **
## uof_lag         0.2409374   0.0943712   2.553  0.01142 *
## stops_lag       0.0032860   0.0157758   0.208  0.83521
## shoot_lag      -3.6088769   2.7283081  -1.323  0.18742
## tmax_f          0.0004023   0.0002739   1.469  0.14338
## snow_in         0.0116618   0.0118124   0.987  0.32471
## precip_in      -0.0772824   0.0415641  -1.859  0.06444 .
## dplyr::lag(white_mh_incid_c, 1)  0.4573811   0.0695599   6.575  4.1e-10 ***
## dplyr::lag(white_mh_incid_c, 2)  0.2006716   0.0754443   2.660  0.00845 **
## dplyr::lag(white_mh_incid_c, 3)  0.1099192   0.0712538   1.543  0.12449
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.06272 on 201 degrees of freedom
## (44 observations deleted due to missingness)
## Multiple R-squared:  0.7117, Adjusted R-squared:  0.6917
## F-statistic: 35.45 on 14 and 201 DF,  p-value: < 2.2e-16

ts_ar3_black <- lm(black_mh_incid_c~t+state_of_emerg+stay_at_home+post_floyd+t_post_floyd+
                  uof_lag+stops_lag+shoot_lag+
                  tmax_f+snow_in+precip_in+
                  dplyr::lag(black_mh_incid_c, 1)+ dplyr::lag(black_mh_incid_c, 2)+
                  dplyr::lag(black_mh_incid_c, 3),
                  data = series)
summary(ts_ar3_black)

```

```
##
## Call:
## lm(formula = black_mh_incid_c ~ t + state_of_emerg + stay_at_home +
##      post_floyd + t_post_floyd + uof_lag + stops_lag + shoot_lag +
##      tmax_f + snow_in + precip_in + dplyr::lag(black_mh_incid_c,
##      1) + dplyr::lag(black_mh_incid_c, 2) + dplyr::lag(black_mh_incid_c,
##      3), data = series)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.36839 -0.09540  0.00568  0.08856  0.38696
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1.5119944   0.7755315    1.950 0.052612 .
## t                -0.0052704   0.0032778   -1.608 0.109430
## state_of_emerg1  -0.2775568   0.0884554   -3.138 0.001958 **
## stay_at_home1     0.1934573   0.0908775    2.129 0.034491 *
## post_floyd1       0.2276755   0.0944241    2.411 0.016800 *
## t_post_floyd     -0.0065160   0.0033862   -1.924 0.055731 .
## uof_lag           0.1122348   0.2087306    0.538 0.591378
## stops_lag         0.0400787   0.0347849    1.152 0.250613
## shoot_lag         0.9174678   6.0390611    0.152 0.879401
## tmax_f            0.0002117   0.0006119    0.346 0.729732
## snow_in           -0.0014666   0.0262880   -0.056 0.955563
## precip_in         -0.1545481   0.0919805   -1.680 0.094467 .
## dplyr::lag(black_mh_incid_c, 1)  0.3398593   0.0687560    4.943 1.62e-06 ***
## dplyr::lag(black_mh_incid_c, 2)  0.1749467   0.0712258    2.456 0.014889 *
## dplyr::lag(black_mh_incid_c, 3)  0.2308650   0.0691262    3.340 0.000999 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1395 on 201 degrees of freedom
## (44 observations deleted due to missingness)
## Multiple R-squared:  0.7486, Adjusted R-squared:  0.7311
## F-statistic: 42.75 on 14 and 201 DF, p-value: < 2.2e-16

ts_ar3_latin <- lm(latin_mh_incid_c~t+state_of_emerg+stay_at_home+post_floyd+t_post_floyd+
                    uof_lag+stops_lag+shoot_lag+
                    tmax_f+snow_in+precip_in+
                    dplyr::lag(latin_mh_incid_c, 1)+ dplyr::lag(latin_mh_incid_c, 2)+
                    dplyr::lag(latin_mh_incid_c, 3),
                    data = series)
summary(ts_ar3_latin)

##
## Call:
## lm(formula = latin_mh_incid_c ~ t + state_of_emerg + stay_at_home +
##      post_floyd + t_post_floyd + uof_lag + stops_lag + shoot_lag +
##      tmax_f + snow_in + precip_in + dplyr::lag(latin_mh_incid_c,
##      1) + dplyr::lag(latin_mh_incid_c, 2) + dplyr::lag(latin_mh_incid_c,
##      3), data = series)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```



```
## -0.32579 -0.08927 -0.00465 0.07260 0.46798
##
## Coefficients:
##
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.3746036 0.7223009 0.519 0.6046
## t 0.0004607 0.0031588 0.146 0.8842
## state_of_emerg1 -0.0954767 0.0853309 -1.119 0.2645
## stay_at_home1 -0.0255143 0.0884495 -0.288 0.7733
## post_floyd1 0.0222977 0.0922099 0.242 0.8092
## t_post_floyd -0.0011048 0.0031700 -0.349 0.7278
## uof_lag -0.0464674 0.2038473 -0.228 0.8199
## stops_lag 0.0243096 0.0338002 0.719 0.4728
## shoot_lag -0.7723934 5.9016926 -0.131 0.8960
## tmax_f 0.0006489 0.0005994 1.083 0.2803
## snow_in -0.0166781 0.0258966 -0.644 0.5203
## precip_in -0.0139046 0.0906698 -0.153 0.8783
## dplyr::lag(latin_mh_incid_c, 1) 0.0758069 0.0708497 1.070 0.2859
## dplyr::lag(latin_mh_incid_c, 2) 0.1223659 0.0705450 1.735 0.0843
## dplyr::lag(latin_mh_incid_c, 3) 0.1008496 0.0707014 1.426 0.1553
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1366 on 201 degrees of freedom
## (44 observations deleted due to missingness)
## Multiple R-squared: 0.3949, Adjusted R-squared: 0.3527
## F-statistic: 9.369 on 14 and 201 DF, p-value: 8.675e-16
```

## ZCTA-Week Level Analysis

```
#aggregate to zip-level over years
zip_level <- panel %>%
  group_by(zcta, period) %>%
    summarize(mh_all_tot = sum(mh_all_tot, na.rm = T),
              total_pop = sum(total_pop, na.rm = T)) %>%
  mutate(mh_incid_c = (mh_all_tot/total_pop)*1000) %>%
  ungroup() %>%
  left_join(zcta, by = "zcta")

#george floyd square
gfs <- geocode("George Floyd Square, Minneapolis", output = "latlon") %>%
  st_as_sf(coords = c("lon", "lat"), crs = "NAD83", remove=F) %>%
  mutate(name = "George Floyd Square")

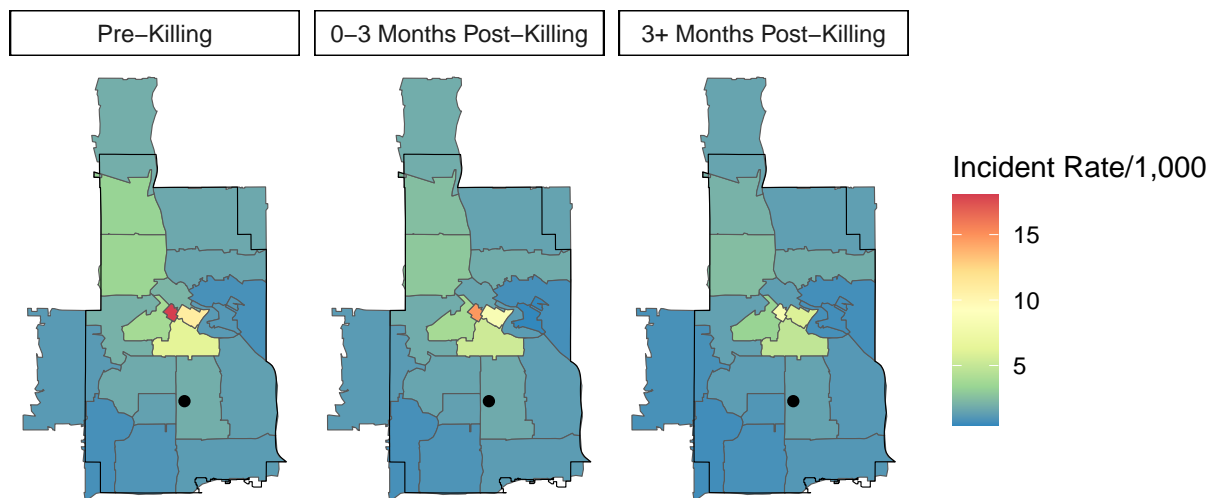
ggplot() +
  geom_sf(data = zip_level, aes(geometry = geometry, fill = mh_incid_c)) +
  geom_sf(data = mpls, aes(geometry = geometry), color = "black", alpha = 0)+
  geom_sf(data = gfs, aes(geometry = geometry), color = "black")+
  # geom_text_repel(data = gfs, aes(x=lon, y=lat, label = name),
  #                 size = 2,
  #                 fontface = "bold",
  #                 nudge_x = 1, nudge_y = -1)+
  facet_wrap(~period)+
```

```

scale_fill_distiller(palette = "Spectral")+
labs(title = "Figure X: Mental Health Hospital Discharges by ZCTA and Period",
      subtitle = "MHA Hospital Discharge Data",
      fill = "Incident Rate/1,000")+
theme(axis.text.x = element_blank(),
      axis.text.y = element_blank(),
      axis.line = element_blank(),
      axis.ticks = element_blank(),
      panel.border = element_blank(),
      panel.grid = element_blank(),
      axis.title = element_blank(),
      panel.background = element_blank(),
      panel.grid.major = element_line(colour="transparent"),
      plot.subtitle = element_text(face="italic"),
      strip.background = element_rect(fill = "white",
                                      colour = "black"))

```

Figure X: Mental Health Hospital Discharges by ZCTA and Period  
*MHA Hospital Discharge Data*



## Panel Analysis

```

## Warning: package 'lme4' was built under R version 4.2.2
## Warning: package 'Matrix' was built under R version 4.2.2
## Warning: package 'lmerTest' was built under R version 4.2.2
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]

```

```

## Formula: mh_all_incid_c ~ 1 + (1 | zcta) + (1 | weekofyr)
## Data: panel
##
## REML criterion at convergence: 74881.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -8.4375 -0.1555 -0.0057  0.1390 12.0060
##
## Random effects:
## Groups Name Variance Std.Dev.
## weekofyr (Intercept) 178.1 13.34
## zcta (Intercept) 148074.4 384.80
## Residual 33094.3 181.92
## Number of obs: 5641, groups: weekofyr, 53; zcta, 22
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 309.44 82.10 21.02 3.769 0.00113 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: mh_all_incid_c ~ t + state_of_emerg + stay_at_home + post_floyd +
## t_post_floyd + uof_lag + stops_lag + shoot_lag + tmax_f +
## snow_in + precip_in + (1 | zcta) + (1 | weekofyr)
## Data: panel
##
## REML criterion at convergence: 74380.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -8.6605 -0.1751 -0.0213  0.1507 12.1244
##
## Random effects:
## Groups Name Variance Std.Dev.
## weekofyr (Intercept) 69.06 8.311
## zcta (Intercept) 148116.78 384.859
## Residual 32144.01 179.288
## Number of obs: 5620, groups: weekofyr, 53; zcta, 22
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 1348.93651 203.71554 652.45396 6.622 7.42e-11 ***
## t -4.47619 0.80331 2452.07929 -5.572 2.79e-08 ***
## state_of_emerg -13.88623 24.06219 1384.45404 -0.577 0.5640
## stay_at_home -48.07492 24.85237 1316.97702 -1.934 0.0533 .
## post_floyd -6.17890 25.33862 1738.27627 -0.244 0.8074
## t_post_floyd -4.54932 0.80300 2521.04833 -5.665 1.63e-08 ***
## uof_lag -0.46123 0.84260 5581.55581 -0.547 0.5841
## stops_lag 0.02324 0.11991 5577.74783 0.194 0.8463
## shoot_lag -4.62568 15.86197 5583.00732 -0.292 0.7706
## tmax_f 0.16284 0.14856 130.88925 1.096 0.2750

```

```

## snow_in          7.75637    7.06640  924.70795    1.098    0.2726
## precip_in        7.28844   23.73931 1248.17325    0.307    0.7589
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr) t          stt_f_ sty_t_ pst_fl t_pst_ uof_lg stps_l sht_lg
## t          -0.914
## state_f_mrg  0.136 -0.160
## stay_at_hom -0.164  0.182 -0.823
## post_floyd  0.330 -0.359 -0.787  0.659
## t_post_flyd -0.914  0.998 -0.148  0.182 -0.357
## uof_lag      0.084 -0.099  0.010  0.000  0.018 -0.099
## stops_lag    -0.023  0.000  0.078 -0.030  0.056  0.018  0.002
## shoot_lag    -0.012  0.012  0.005  0.002 -0.007  0.012  0.027  0.018
## tmax_f       -0.207  0.190  0.008 -0.028 -0.170  0.185 -0.045 -0.046  0.018
## snow_in      -0.004 -0.022  0.052 -0.033 -0.046 -0.018 -0.012  0.020  0.016
## precip_in    -0.067  0.079 -0.041  0.044  0.032  0.080 -0.002  0.020 -0.010
##          tmax_f snow_n
## t
## state_f_mrg
## stay_at_hom
## post_floyd
## t_post_flyd
## uof_lag
## stops_lag
## shoot_lag
## tmax_f
## snow_in      0.479
## precip_in    -0.381 -0.240

## Warning: Some predictor variables are on very different scales: consider
## rescaling

## Warning: Some predictor variables are on very different scales: consider
## rescaling

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: mh_all_incid_c ~ t + state_of_emerg + stay_at_home + post_floyd +
##          t_post_floyd + uof_lag + stops_lag + shoot_lag + tmax_f +
##          snow_in + precip_in + black_pop + post_floyd:black_pop +
##          (1 + post_floyd | zcta)
## Data: panel
##
## REML criterion at convergence: 73918.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -9.5154 -0.1658 -0.0063  0.1514 12.2148
##
## Random effects:
## Groups   Name                Variance Std.Dev. Corr
## zcta     (Intercept) 164191    405.2
##          post_floyd1  25195    158.7   -0.99

```

```

## Residual                29519   171.8
## Number of obs: 5620, groups: zcta, 22
##
## Fixed effects:
##
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)    1.390e+03  1.994e+02  5.342e+02   6.972 9.24e-12 ***
## t              -4.463e+00  7.605e-01  5.576e+03  -5.868 4.66e-09 ***
## state_of_emerg -9.486e+00  2.264e+01  5.570e+03  -0.419  0.6752
## stay_at_home   -5.174e+01  2.336e+01  5.569e+03  -2.215  0.0268 *
## post_floyd1    -4.104e+01  4.434e+01  5.229e+01  -0.926  0.3589
## t_post_floyd   -4.543e+00  7.605e-01  5.576e+03  -5.974 2.46e-09 ***
## uof_lag        -7.772e-01  8.077e-01  5.522e+03  -0.962  0.3360
## stops_lag       9.073e-02  1.173e-01  5.582e+03   0.773  0.4393
## shoot_lag      -5.528e+00  1.519e+01  5.572e+03  -0.364  0.7160
## tmax_f         1.683e-01  1.339e-01  5.566e+03   1.257  0.2088
## snow_in        8.368e+00  6.614e+00  5.567e+03   1.265  0.2059
## precip_in      4.876e+00  2.230e+01  5.566e+03   0.219  0.8269
## black_pop      -1.162e-02  8.459e-03  8.356e+02  -1.374  0.1699
## post_floyd1:black_pop 8.163e-03  4.001e-03  1.389e+02   2.040  0.0432 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## fit warnings:
## Some predictor variables are on very different scales: consider rescaling
## Warning: package 'sjPlot' was built under R version 4.2.2
## Warning in checkMatrixPackageVersion(): Package version inconsistency detected.
## TMB was built with Matrix version 1.5.1
## Current Matrix version is 1.5.3
## Please re-install 'TMB' from source using install.packages('TMB', type = 'source') or ask CRAN for a

```

## Random effects

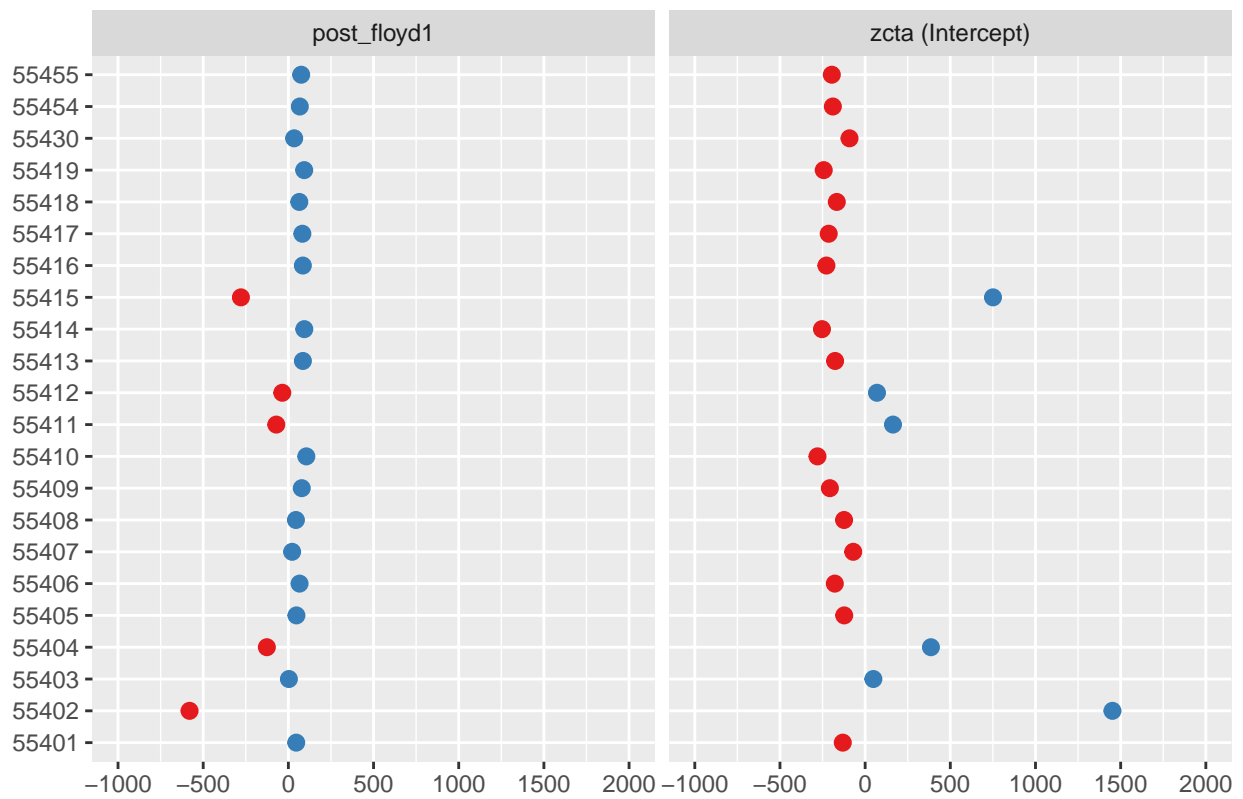


Figure X: Post-Killing X Percent Black Interaction Plot

