# Gun Series

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## Base Panel Construction - ZCTA-Week Level

### Hospital Data - ZCTA-Week level

```
hosp_zcta <- read_csv("Restricted Hospital Data/minnepop_1620_agg_zipfull_updated.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)

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)) %>%
  mutate_at(vars(-zcta, -year, -total_pop, -med_age), list(~(./total_pop)*100))

#LOCF imputation of 2020 until 2020 ACS release (12/9/2021)
acs_2020 <- acs %>%
  complete(zcta, year = 2016:2020) %>%
  group_by(zcta) %>%
  mutate_at(vars(-zcta, -year),
            funs(if(sum(!is.na(.))<1) {.} else{na_locf(., option = "locf")})) %>%
  filter(year==2020)

acs_imp <- acs %>%
  rbind(acs_2020) %>%
  mutate(zcta = as.numeric(zcta))

#joining to hospital data
hosp_panel <- hosp_zcta %>%
  left_join(acs_imp, by = c("zipcode"="zcta", "year"))

#SF geometries - get all ZCTAs
zcta <- get_acs(geography = "zcta",
                    variables = "B01001_001",
                    output = "wide",
                    year = 2019,
                    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:\Users
##   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 %>%
  filter(ifelse(lengths(st_intersects(., mpls)) > 0, 1, 0)==1) %>%
  select(zcta)

#which zctas are not in hosp data but still intersect MPLS
setdiff(unique(zcta_intersect$zcta), unique(hosp_zcta$zipcode))
```

```
## [1] 55114 55105 55104 55113 55116 55111 55108
```

```
#joining to panel, filter to those ZCTAs intersecting MPLS
panel <- zcta %>%
  left_join(hosp_panel, by = c("zcta"="zipcode")) %>%
  filter(ifelse(lengths(st_intersects(., mpls)) > 0, 1, 0)==1 &
           zcta >= 55401)  #queen contiguity

#creating date bookends
panel <- panel %>%
  group_by(zcta, 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 <= 2020 & 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)),
         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))
```

# 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(assault_tot = sum(assault_tot, na.rm = T),
            unintent_tot = sum(unintent_tot, na.rm = T),
            suicide_tot = sum(suicide_tot, na.rm = T),
            undeter_tot = sum(undeter_tot, na.rm = T),
            legal_tot = sum(legal_tot, na.rm = T),
            combined_tot = sum(combined_tot, na.rm = T),
            total_pop = sum(total_pop, na.rm = T)) %>%
```

```
  mutate(assault_incid_c = (assault_tot/total_pop)*1000,
         unintent_incid_c = (unintent_tot/total_pop)*1000,
         suicide_incid_c = (suicide_tot/total_pop)*1000,
         undeter_incid_c = (undeter_tot/total_pop)*1000,
         legal_incid_c = (legal_tot/total_pop)*1000,
         combined_incid_c = (combined_tot/total_pop)*1000) %>%
  ungroup() %>%
  mutate(week_id = row_number()) %>%
  st_drop_geometry()
```

### 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_stops = ifelse(is.na(police_stops), 0, police_stops),
         police_stop_rate = (police_stops/total_pop)*1000)


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

# Weather Data

```
# Minnesota DNR Daily Date
 # https://www.dnr.state.mn.us/climate/historical/daily-data.html?sid=mspthr&sname=Minneapolis/St%20Pau
 # 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 series
series <- series %>% left_join(weather, by = c("year","weekofyr"="week"))
```

## Sunset Data

```
#setting lat-lon for MPLS
mpls_lonlat <- geocode("Minneapolis, MN", output = "latlon", source="google")

#scrape sunset times for each begin date
  #mutate to UTC-6 CST
  #calculate hours of darkness before midnight
sun_series <- getSunlightTimes(date = seq(min(series$begin_date),
                               max(series$begin_date),
                               "days"),
```

```
                                lat = 44.97775   ,
                                lon = -93.26501,
                                keep = "sunset",
                                tz = "UTC") %>%
  mutate(sunset = sunset-hours(6),
         midnight = as.POSIXlt(date+days(1), format = '%Y-%m-%d %H:%M:%S'),
         dark = as.numeric(midnight-sunset),
         year = year(date),
         week = isoweek(date)) %>%
  group_by(year, week) %>%
  summarize(dark_before_12 = mean(dark, na.rm = T))


#joining to series
series <- series %>%
  left_join(sun_series, by = c("year", "weekofyr"="week"))
```

### School Data

```
#created manually from online MPLS Public School Calendars: https://mpls.k12.mn.us/calendars
school <- series %>%
  select(year, weekofyr, begin_date, end_date) %>%
  mutate(days_in_week = as.numeric((end_date-begin_date))+1,
         days_in_school = NA_integer_)

school[1,6] <- 5
school[2,6] <- 4
school[3,6] <- 3
school[4,6] <- 5
school[5,6] <- 5
school[6,6] <- 4
school[7,6] <- 4
school[8,6] <- 5
school[9,6] <- 5
school[10,6] <- 4
school[11,6] <- 4
school[12,6] <- 5
school[13,6] <- 0
school[14,6] <- 5
school[15,6] <- 5
school[16,6] <- 5
school[17,6] <- 5
school[18,6] <- 5
school[19,6] <- 5
school[20,6] <- 5
school[21,6] <- 5
school[22,6] <- 4
school[23,6] <- 2
school[24,6] <- 0
school[25,6] <- 0
school[26,6] <- 0
```

```
school[27,6] <- 0
school[28,6] <- 0
school[29,6] <- 0
school[30,6] <- 0
school[31,6] <- 0
school[32,6] <- 0
school[33,6] <- 0
school[34,6] <- 0
school[35,6] <- 5
school[36,6] <- 4
school[37,6] <- 5
school[38,6] <- 5
school[39,6] <- 5
school[40,6] <- 5
school[41,6] <- 5
school[42,6] <- 2
school[43,6] <- 5
school[44,6] <- 3
school[45,6] <- 5
school[46,6] <- 5
school[47,6] <- 2
school[48,6] <- 5
school[49,6] <- 5
school[50,6] <- 5
school[51,6] <- 0
school[52,6] <- 0
school[53,6] <- 4
school[54,6] <- 5
school[55,6] <- 4
school[56,6] <- 4
school[57,6] <- 4
school[58,6] <- 5
school[59,6] <- 4
school[60,6] <- 4
school[61,6] <- 5
school[62,6] <- 5
school[63,6] <- 5
school[64,6] <- 5
school[65,6] <- 3
school[66,6] <- 0
school[67,6] <- 5
school[68,6] <- 5
school[69,6] <- 5
school[70,6] <- 5
school[71,6] <- 5
school[72,6] <- 5
school[73,6] <- 5
school[74,6] <- 4
school[75,6] <- 5
school[76,6] <- 3
school[77,6] <- 0
school[78,6] <- 0
school[79,6] <- 0
```

```
school[80,6] <- 0
school[81,6] <- 0
school[82,6] <- 0
school[83,6] <- 0
school[84,6] <- 0
school[85,6] <- 0
school[86,6] <- 0
school[87,6] <- 5
school[88,6] <- 4
school[89,6] <- 5
school[90,6] <- 5
school[91,6] <- 5
school[92,6] <- 5
school[93,6] <- 5
school[94,6] <- 2
school[95,6] <- 5
school[96,6] <- 3
school[97,6] <- 5
school[98,6] <- 5
school[99,6] <- 2
school[100,6] <- 5
school[101,6] <- 5
school[102,6] <- 5
school[103,6] <- 5
school[104,6] <- 0
school[105,6] <- 0
school[106,6] <- 0
school[107,6] <- 5
school[108,6] <- 4
school[109,6] <- 3
school[110,6] <- 5
school[111,6] <- 5
school[112,6] <- 4
school[113,6] <- 4
school[114,6] <- 5
school[115,6] <- 5
school[116,6] <- 5
school[117,6] <- 5
school[118,6] <- 4
school[119,6] <- 0
school[120,6] <- 5
school[121,6] <- 5
school[122,6] <- 5
school[123,6] <- 5
school[124,6] <- 5
school[125,6] <- 5
school[126,6] <- 5
school[127,6] <- 4
school[128,6] <- 5
school[129,6] <- 0
school[130,6] <- 0
school[131,6] <- 0
school[132,6] <- 0
```

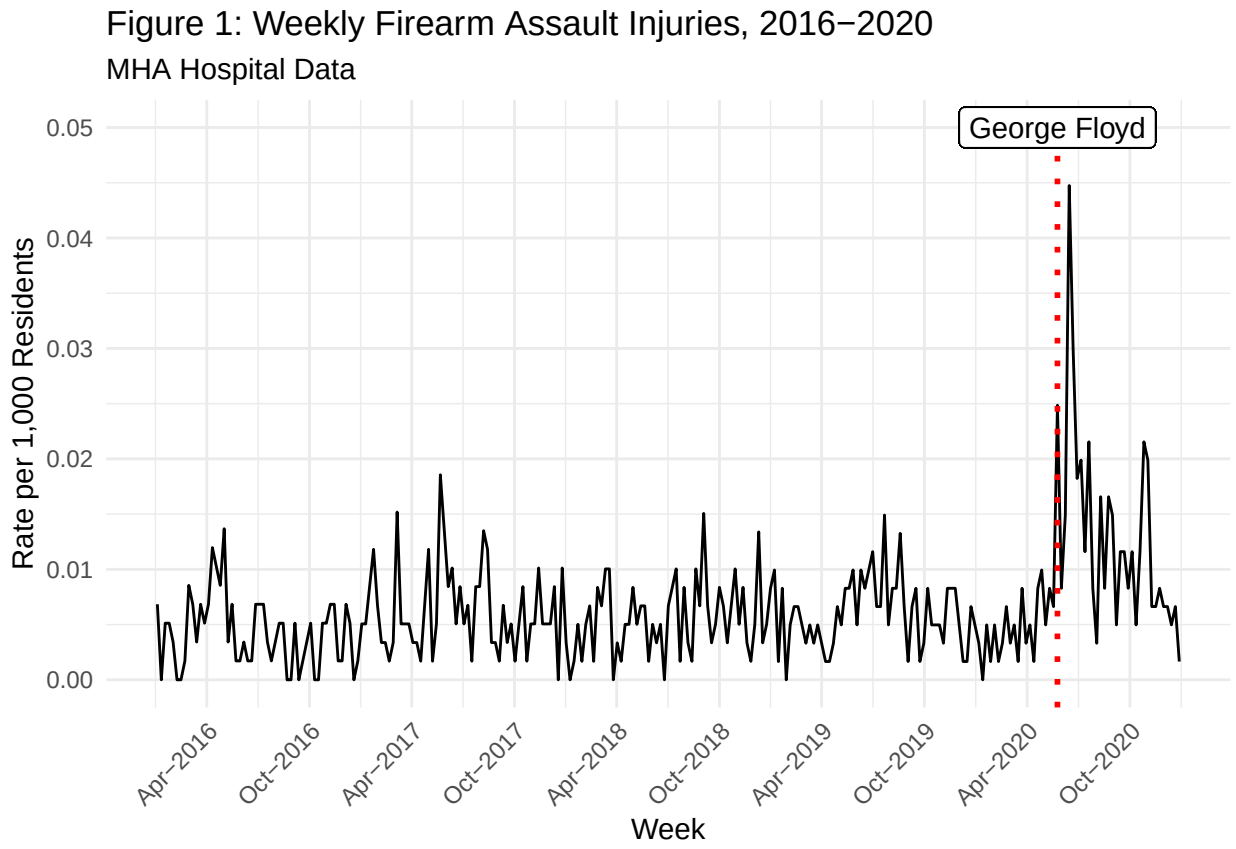
```
school[133,6] <- 0
school[134,6] <- 0
school[135,6] <- 0
school[136,6] <- 0
school[137,6] <- 0
school[138,6] <- 0
school[139,6] <- 0
school[140,6] <- 5
school[141,6] <- 4
school[142,6] <- 5
school[143,6] <- 5
school[144,6] <- 5
school[145,6] <- 5
school[146,6] <- 5
school[147,6] <- 2
school[148,6] <- 5
school[149,6] <- 3
school[150,6] <- 5
school[151,6] <- 5
school[152,6] <- 2
school[153,6] <- 5
school[154,6] <- 5
school[155,6] <- 5
school[156,6] <- 5
school[157,6] <- 0
school[158,6] <- 0
school[159,6] <- 5
school[160,6] <- 5
school[161,6] <- 2
school[162,6] <- 5
school[163,6] <- 5
school[164,6] <- 4
school[165,6] <- 4
school[166,6] <- 5
school[167,6] <- 5
school[168,6] <- 5
school[169,6] <- 5
school[170,6] <- 4
school[171,6] <- 0
school[172,6] <- 5
school[173,6] <- 5
school[174,6] <- 5
school[175,6] <- 5
school[176,6] <- 5
school[177,6] <- 5
school[178,6] <- 5
school[179,6] <- 4
school[180,6] <- 5
school[181,6] <- 0
school[182,6] <- 0
school[183,6] <- 0
school[184,6] <- 0
school[185,6] <- 0
```

```
school[186,6] <- 0
school[187,6] <- 0
school[188,6] <- 0
school[189,6] <- 0
school[190,6] <- 0
school[191,6] <- 0
school[192,6] <- 0
school[193,6] <- 4
school[194,6] <- 5
school[195,6] <- 5
school[196,6] <- 5
school[197,6] <- 5
school[198,6] <- 5
school[199,6] <- 2
school[200,6] <- 5
school[201,6] <- 4
school[202,6] <- 5
school[203,6] <- 5
school[204,6] <- 5
school[205,6] <- 2
school[206,6] <- 5
school[207,6] <- 5
school[208,6] <- 5
school[209,6] <- 0
school[210,6] <- 0
school[211,6] <- 5
school[212,6] <- 4
school[213,6] <- 4
school[214,6] <- 5
school[215,6] <- 5
school[216,6] <- 5
school[217,6] <- 3
school[218,6] <- 5
school[219,6] <- 5
school[220,6] <- 5
school[221,6] <- 5
school[222,6] <- 4
school[223,6] <- 0
school[224,6] <- 5
school[225,6] <- 5
school[226,6] <- 5
school[227,6] <- 5
school[228,6] <- 5
school[229,6] <- 5
school[230,6] <- 5
school[231,6] <- 4
school[232,6] <- 5
school[233,6] <- 0
school[234,6] <- 0
school[235,6] <- 0
school[236,6] <- 0
school[237,6] <- 0
school[238,6] <- 0
```

```
school[239,6] <- 0
school[240,6] <- 0
school[241,6] <- 0
school[242,6] <- 0
school[243,6] <- 0
school[244,6] <- 0
school[245,6] <- 4
school[246,6] <- 5
school[247,6] <- 5
school[248,6] <- 5
school[249,6] <- 5
school[250,6] <- 5
school[251,6] <- 3
school[252,6] <- 4
school[253,6] <- 5
school[254,6] <- 4
school[255,6] <- 5
school[256,6] <- 5
school[257,6] <- 2
school[258,6] <- 5
school[259,6] <- 5
school[260,6] <- 5
school[261,6] <- 0
school[262,6] <- 0

school <- school %>%
  mutate(school = days_in_school/days_in_week) %>%
  select(year, weekofyr, school)

series <- series %>% left_join(school, by = c("year", "weekofyr"))
```

### Time Series Vizualization

```
ggplot(series)+
  geom_line(aes(x=begin_date, y=assault_incid_c))+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_vline(xintercept=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25
             linetype="dotted", color="red", size=1)+
  geom_label(aes(x=series$begin_date[series$year==2020 & series$weekofyr==isoweek(date("2020-05-25"))],
                 y=0.050),
             label = "George Floyd", show.legend = FALSE)+
  labs(title = "Figure 1: Weekly Firearm Assault Injuries, 2016-2020",
       subtitle = "MHA Hospital Data",
       x = "Week",
       y = "Rate per 1,000 Residents")+
  theme_minimal()+
    theme(axis.text.x=element_text(angle=45, hjust=1))
```



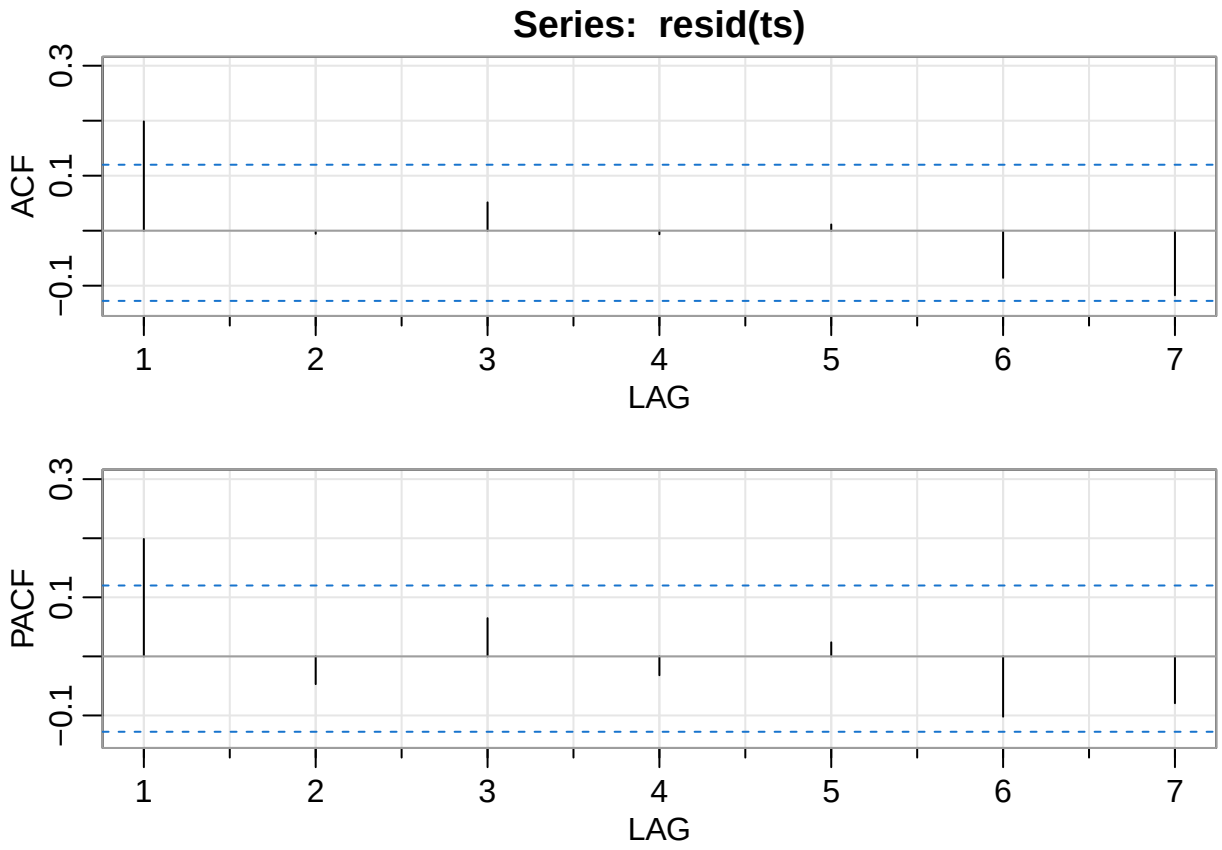

### Time Series Analysis

```
series <- series %>%
  mutate(t = 1:length(assault_incid_c),
         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)),
         stay_at_home = as.numeric(begin_date >= as.Date("2020-03-28") &
         state_of_emerg = as.numeric(begin_date >= as.Date("2020-03-13")),
         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(assault_incid_c~t+state_of_emerg+stay_at_home+post_floyd+post_floyd_3+
                         tmax_f+snow_in+precip_in+dark_before_12+school,
                         data = series)
summary(ts)
```

```
##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school, data = series)
##
```

```
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0139072 -0.0025135 -0.0002368  0.0018088  0.0273037
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     6.637e-03  3.557e-03   1.866   0.0633 .
## t               6.573e-06  4.524e-06   1.453   0.1475
## state_of_emerg -3.394e-03  2.573e-03  -1.319   0.1883
## stay_at_home    3.078e-03  2.646e-03   1.163   0.2459
## post_floyd      1.360e-02  2.631e-03   5.167 4.86e-07 ***
## post_floyd_3   -6.644e-03  1.633e-03  -4.068 6.36e-05 ***
## tmax_f          1.333e-05  2.415e-05   0.552   0.5814
## snow_in        -5.169e-04  7.725e-04  -0.669   0.5041
## precip_in      -2.400e-04  2.524e-03  -0.095   0.9243
## dark_before_12 -5.074e-04  4.136e-04  -1.227   0.2211
## school          7.116e-04  9.511e-04   0.748   0.4551
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.004188 on 250 degrees of freedom
## Multiple R-squared:  0.3509, Adjusted R-squared:  0.325
## F-statistic: 13.52 on 10 and 250 DF,  p-value: < 2.2e-16
```

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

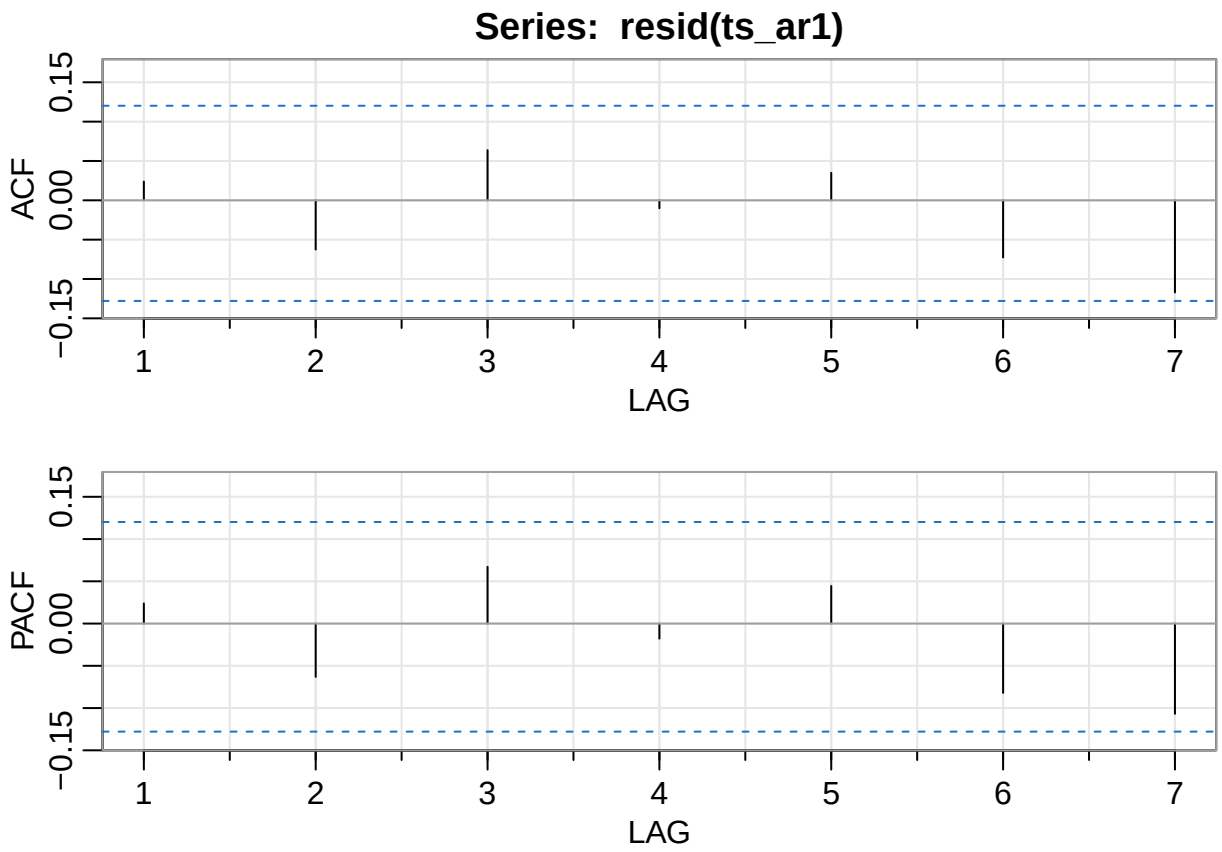


```
##      [,1]  [,2] [,3]  [,4] [,5]  [,6]  [,7]
## ACF   0.2 -0.01 0.05 -0.01 0.01 -0.09 -0.12
## PACF  0.2 -0.05 0.06 -0.03 0.02 -0.10 -0.08
```

```
ts_ar1<- lm(assault_incid_c~t+state_of_emerg+stay_at_home+post_floyd+post_floyd_3+
                        tmax_f+snow_in+precip_in+dark_before_12+school+
                        dplyr::lag(assault_incid_c, 1), data = series)
summary(ts_ar1)
```

```
##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + dplyr::lag(assault_incid_c, 1),
##     data = series)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0122313 -0.0026183 -0.0002489  0.0020128  0.0277111
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     5.373e-03  3.528e-03   1.523  0.12902
## t                               5.744e-06  4.512e-06   1.273  0.20425
## state_of_emerg                 -3.649e-03  2.535e-03  -1.439  0.15128
## stay_at_home                    3.529e-03  2.611e-03   1.352  0.17769
## post_floyd                      1.202e-02  2.642e-03   4.548 8.49e-06 ***
## post_floyd_3                   -5.645e-03  1.641e-03  -3.441  0.00068 ***
## tmax_f                          1.031e-05  2.383e-05   0.433  0.66551
## snow_in                        -4.415e-04  7.613e-04  -0.580  0.56252
## precip_in                       1.817e-04  2.490e-03   0.073  0.94190
## dark_before_12                 -4.423e-04  4.083e-04  -1.083  0.27983
## school                          8.569e-04  9.383e-04   0.913  0.36199
## dplyr::lag(assault_incid_c, 1)  1.863e-01  6.179e-02   3.015  0.00284 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.004125 on 248 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.3753, Adjusted R-squared:  0.3476
## F-statistic: 13.54 on 11 and 248 DF,  p-value: < 2.2e-16
```

```
acf2(resid(ts_ar1), max.lag = 7)
```



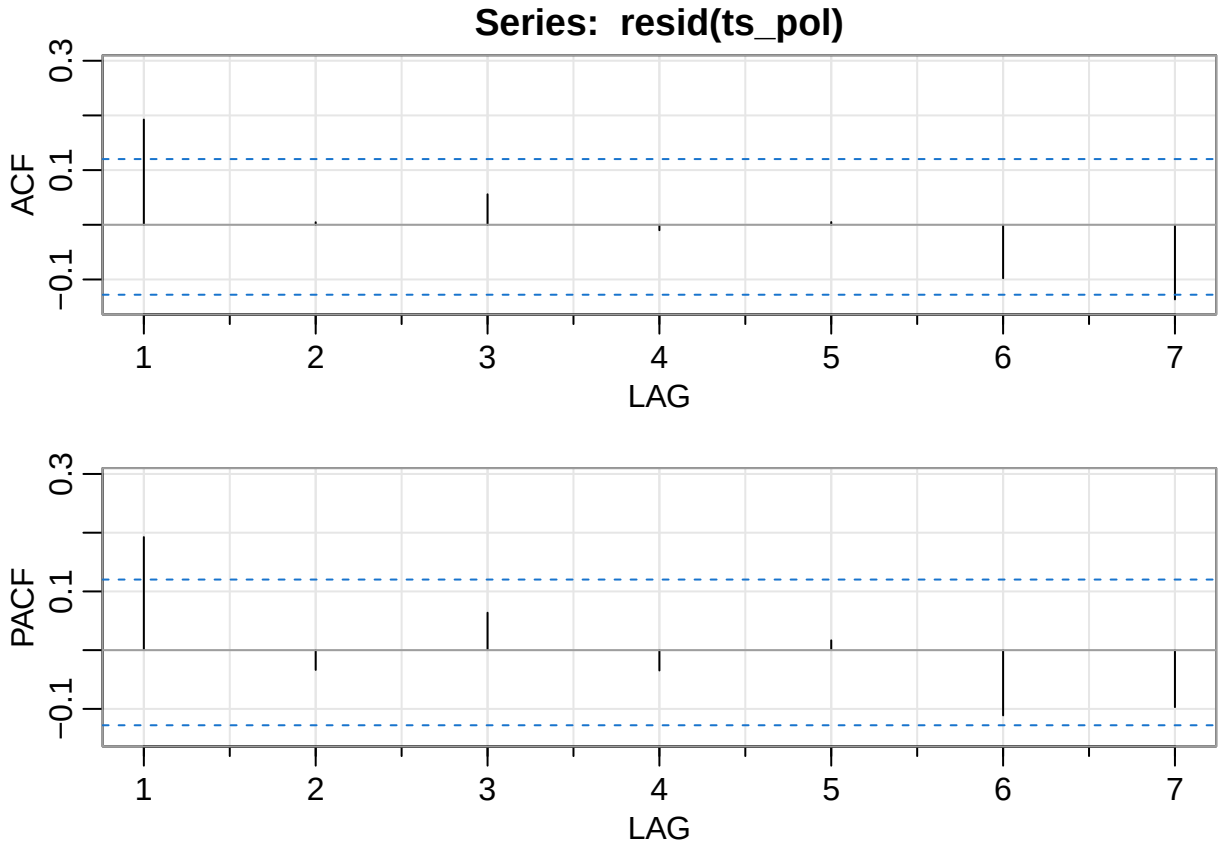

```
##      [,1]  [,2] [,3]  [,4] [,5]  [,6]  [,7]
## ACF  0.02 -0.06 0.06 -0.01 0.03 -0.07 -0.12
## PACF 0.02 -0.06 0.07 -0.02 0.04 -0.08 -0.11
```

```
ts_pol <- lm(assault_incid_c~t+state_of_emerg+stay_at_home+post_floyd+post_floyd_3+
                        tmax_f+snow_in+precip_in+dark_before_12+school+
                        uof_lag+stops_lag+shoot_lag,
                        data = series)
summary(ts_pol)
```

```
##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + uof_lag + stops_lag + shoot_lag,
##     data = series)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0140949 -0.0026548 -0.0002571  0.0018680  0.0271987
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     6.496e-03  3.622e-03   1.794  0.07410 .
## t               4.143e-06  4.997e-06   0.829  0.40788
```

```
## state_of_emerg -3.131e-03  2.595e-03  -1.207  0.22867
## stay_at_home    2.982e-03  2.647e-03   1.127  0.26095
## post_floyd      1.376e-02  2.641e-03   5.212 3.96e-07 ***
## post_floyd_3   -5.852e-03  1.803e-03  -3.246  0.00133 **
## tmax_f          1.403e-05  2.418e-05   0.580  0.56241
## snow_in        -5.236e-04  7.744e-04  -0.676  0.49959
## precip_in       7.839e-05  2.531e-03   0.031  0.97532
## dark_before_12 -4.575e-04  4.157e-04  -1.101  0.27217
## school          5.299e-04  9.556e-04   0.554  0.57974
## uof_lag        -8.392e-03  8.067e-03  -1.040  0.29920
## stops_lag       6.294e-04  4.709e-04   1.337  0.18256
## shoot_lag      -1.701e-01  2.259e-01  -0.753  0.45217
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.004187 on 246 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.3616, Adjusted R-squared:  0.3279
## F-statistic: 10.72 on 13 and 246 DF,  p-value: < 2.2e-16
```

```
acf2(resid(ts_pol), max.lag = 7)
```

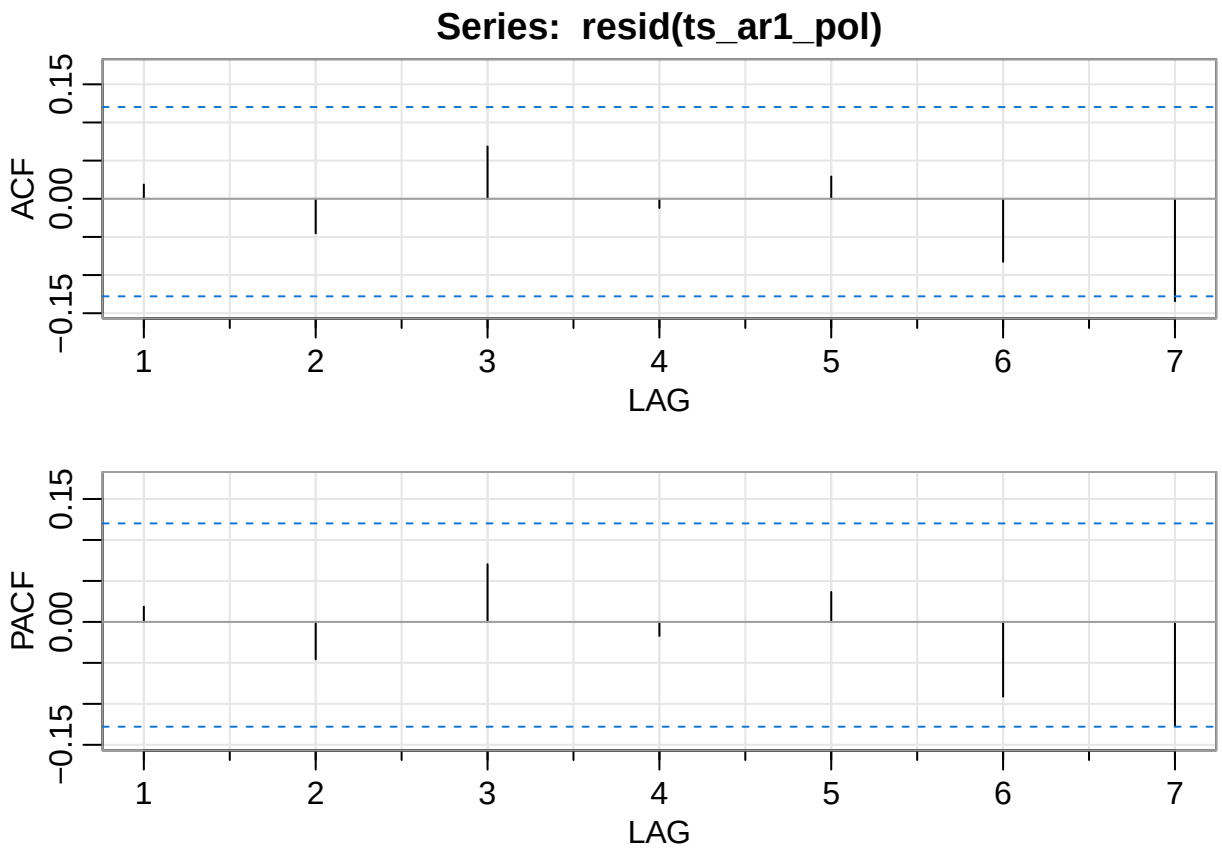



```
##      [,1]  [,2] [,3]  [,4] [,5]  [,6]  [,7]
## ACF  0.19  0.00 0.06 -0.01 0.00 -0.10 -0.14
## PACF 0.19 -0.03 0.06 -0.03 0.02 -0.11 -0.10
```

```r
ts_ar1_pol<- lm(assault_incid_c~t+state_of_emerg+stay_at_home+post_floyd+post_floyd_3+
                        tmax_f+snow_in+precip_in+dark_before_12+school+
                  uof_lag+stops_lag+shoot_lag+
                        dplyr::lag(assault_incid_c, 1), data = series)


summary(ts_ar1_pol)
```

```
##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + uof_lag + stops_lag + shoot_lag +
##     dplyr::lag(assault_incid_c, 1), data = series)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0124598 -0.0025174 -0.0003879  0.0021404  0.0275611
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     5.455e-03  3.584e-03   1.522  0.12924
## t                               3.311e-06  4.929e-06   0.672  0.50234
## state_of_emerg                 -3.428e-03  2.557e-03  -1.341  0.18129
## stay_at_home                    3.454e-03  2.611e-03   1.323  0.18712
## post_floyd                      1.218e-02  2.655e-03   4.590 7.09e-06 ***
## post_floyd_3                   -4.812e-03  1.810e-03  -2.659  0.00835 **
## tmax_f                          1.083e-05  2.384e-05   0.454  0.65014
## snow_in                        -4.529e-04  7.629e-04  -0.594  0.55331
## precip_in                       4.554e-04  2.495e-03   0.183  0.85534
## dark_before_12                 -3.921e-04  4.099e-04  -0.956  0.33979
## school                          6.973e-04  9.427e-04   0.740  0.46021
## uof_lag                        -9.394e-03  7.950e-03  -1.182  0.23852
## stops_lag                       5.243e-04  4.650e-04   1.128  0.26062
## shoot_lag                      -1.554e-01  2.225e-01  -0.698  0.48561
## dplyr::lag(assault_incid_c, 1)  1.831e-01  6.200e-02   2.952  0.00346 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.004123 on 245 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.3836, Adjusted R-squared:  0.3483
## F-statistic: 10.89 on 14 and 245 DF,  p-value: < 2.2e-16
```

```r
acf2(resid(ts_ar1_pol), max.lag = 7)
```




```
##      [,1]  [,2] [,3]  [,4] [,5]  [,6]  [,7]
## ACF  0.02 -0.05 0.07 -0.01 0.03 -0.08 -0.13
## PACF 0.02 -0.05 0.07 -0.02 0.04 -0.09 -0.13
```

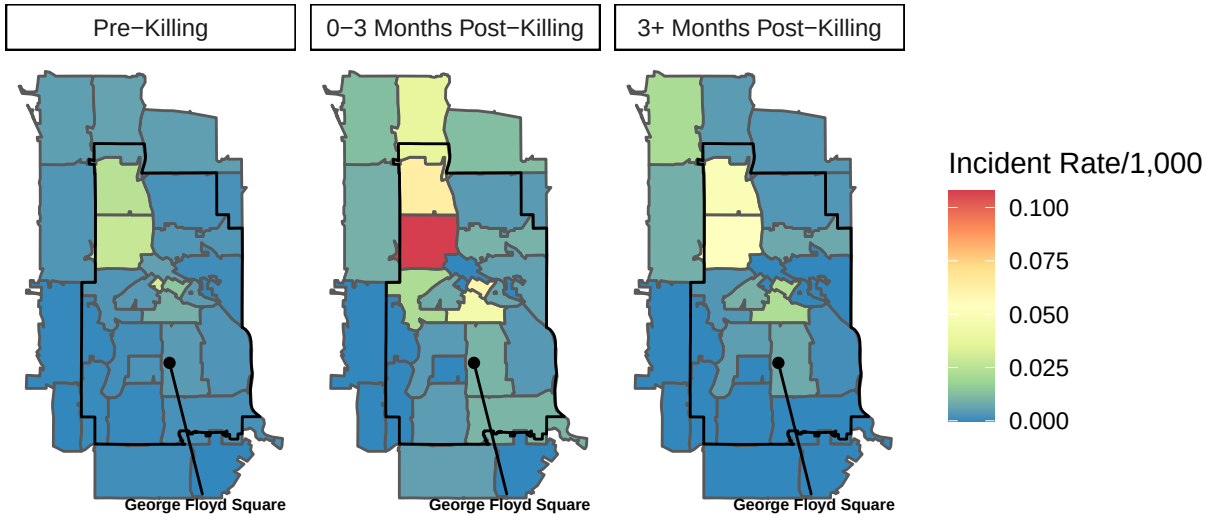
## ZCTA-Week Level Analysis

```
#aggregate to zip-level over years
zip_level <- panel %>%
  group_by(zcta, period) %>%
  summarize(assault_tot = mean(assault_tot, na.rm = T),
            unintent_tot = mean(unintent_tot, na.rm = T),
            suicide_tot = mean(suicide_tot, na.rm = T),
            undeter_tot = mean(undeter_tot, na.rm = T),
            legal_tot = mean(legal_tot, na.rm = T),
            combined_tot = mean(combined_tot, na.rm = T),
            total_pop = mean(total_pop, na.rm = T)) %>%
  mutate(assault_incid_c = (assault_tot/total_pop)*1000,
         unintent_incid_c = (unintent_tot/total_pop)*1000,
         suicide_incid_c = (suicide_tot/total_pop)*1000,
         undeter_incid_c = (undeter_tot/total_pop)*1000,
         legal_incid_c = (legal_tot/total_pop)*1000,
         combined_incid_c = (combined_tot/total_pop)*1000) %>%
  ungroup() %>%
```

```
  st_drop_geometry() %>%
  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 = assault_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 2: Firearm Assault Injury Rates by ZCTA and Period",
       subtitle = "MHA Hospital Discharge Data",
       fill = "Incident Rate/1,000")+
  theme(axis.text = 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 2: Firearm Assault Injury Rates by ZCTA and Period

*MHA Hospital Discharge Data*

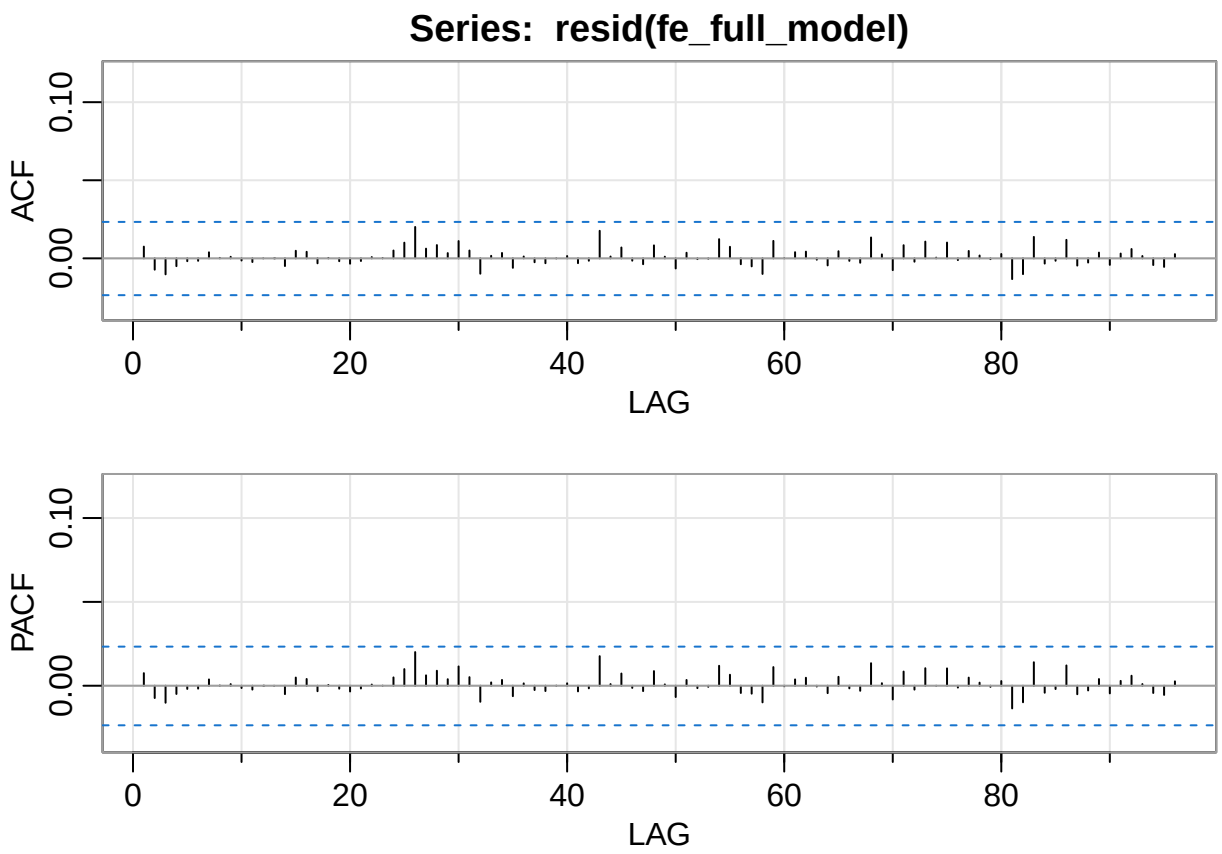



## Panel Analysis

```
##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + as.factor(zcta), data = panel)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -4.349  -0.625  -0.270   0.022 264.043
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)           0.5572515  0.8381086   0.665  0.50614
## t                     0.0022449  0.0009967   2.252  0.02433 *
## state_of_emerg       -0.5300117  0.5660457  -0.936  0.34913
## stay_at_home          0.2300424  0.5822084   0.395  0.69277
## post_floyd            0.9772376  0.5789280   1.688  0.09145 .
## post_floyd_3         -0.4441449  0.3593825  -1.236  0.21655
## tmax_f                0.0028671  0.0053216   0.539  0.59007
## snow_in              -0.0850339  0.1700075  -0.500  0.61697
## precip_in            -0.1840307  0.5556500  -0.331  0.74050
## dark_before_12       -0.0804399  0.0911871  -0.882  0.37773
## school               -0.1524415  0.2093498  -0.728  0.46654
```

```
## as.factor(zcta)55402  2.0188457  0.4268702   4.729 2.29e-06 ***
## as.factor(zcta)55403  0.0171753  0.4268702   0.040  0.96791
## as.factor(zcta)55404  0.7732006  0.4268702   1.811  0.07013 .
## as.factor(zcta)55405 -0.0343970  0.4268702  -0.081  0.93578
## as.factor(zcta)55406 -0.1560144  0.4268702  -0.365  0.71476
## as.factor(zcta)55407  0.0582581  0.4268702   0.136  0.89145
## as.factor(zcta)55408 -0.2586522  0.4268702  -0.606  0.54458
## as.factor(zcta)55409 -0.2364360  0.4268702  -0.554  0.57968
## as.factor(zcta)55410 -0.4089703  0.4268702  -0.958  0.33806
## as.factor(zcta)55411  2.9258866  0.4268702   6.854 7.76e-12 ***
## as.factor(zcta)55412  2.4045153  0.4268702   5.633 1.84e-08 ***
## as.factor(zcta)55413 -0.0592224  0.4268702  -0.139  0.88966
## as.factor(zcta)55414 -0.3227576  0.4268702  -0.756  0.44961
## as.factor(zcta)55415  1.2416106  0.4268702   2.909  0.00364 **
## as.factor(zcta)55416 -0.4414446  0.4268702  -1.034  0.30110
## as.factor(zcta)55417 -0.2190085  0.4268702  -0.513  0.60793
## as.factor(zcta)55418 -0.2264396  0.4268702  -0.530  0.59581
## as.factor(zcta)55419 -0.3964493  0.4268702  -0.929  0.35306
## as.factor(zcta)55421  0.1187478  0.4268702   0.278  0.78088
## as.factor(zcta)55422 -0.0500345  0.4268702  -0.117  0.90670
## as.factor(zcta)55423 -0.3066886  0.4268702  -0.718  0.47250
## as.factor(zcta)55424 -0.4652388  0.4268702  -1.090  0.27580
## as.factor(zcta)55429  0.2386535  0.4268702   0.559  0.57613
## as.factor(zcta)55430  0.3444312  0.4268702   0.807  0.41976
## as.factor(zcta)55450 -0.4776894  0.4311256  -1.108  0.26790
## as.factor(zcta)55454  0.0086534  0.4268702   0.020  0.98383
## as.factor(zcta)55455 -0.4652388  0.4268702  -1.090  0.27580
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.876 on 7260 degrees of freedom
##   (10 observations deleted due to missingness)
## Multiple R-squared:  0.03484,    Adjusted R-squared:  0.02992
## F-statistic: 7.083 on 37 and 7260 DF,  p-value: < 2.2e-16


##
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + uof_lag + stops_lag + shoot_lag +
##     as.factor(zcta), data = panel)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -4.610  -0.654  -0.273   0.036 263.804
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)           0.670981   0.844991   0.794  0.42718
## t                     0.002128   0.001053   2.021  0.04336 *
## state_of_emerg       -0.524791   0.568540  -0.923  0.35601
## stay_at_home          0.220967   0.583276   0.379  0.70482
## post_floyd            0.973902   0.580683   1.677  0.09355 .
## post_floyd_3         -0.344853   0.362656  -0.951  0.34168
```

```
## tmax_f                 0.003259   0.005334   0.611  0.54122
## snow_in               -0.079543   0.170338  -0.467  0.64053
## precip_in             -0.166529   0.556667  -0.299  0.76483
## dark_before_12        -0.079835   0.091488  -0.873  0.38290
## school                -0.149832   0.210028  -0.713  0.47563
## uof_lag               -0.051330   0.023112  -2.221  0.02639 *
## stops_lag              0.001729   0.003212   0.538  0.59031
## shoot_lag             -0.293985   0.431783  -0.681  0.49598
## as.factor(zcta)55402   2.088780   0.429819   4.860 1.20e-06 ***
## as.factor(zcta)55403   0.037945   0.429398   0.088  0.92959
## as.factor(zcta)55404   0.712232   0.433899   1.641  0.10074
## as.factor(zcta)55405  -0.130753   0.430381  -0.304  0.76128
## as.factor(zcta)55406  -0.267428   0.431376  -0.620  0.53532
## as.factor(zcta)55407  -0.027715   0.433533  -0.064  0.94903
## as.factor(zcta)55408  -0.324824   0.447391  -0.726  0.46784
## as.factor(zcta)55409  -0.371963   0.436166  -0.853  0.39380
## as.factor(zcta)55410  -0.542810   0.438870  -1.237  0.21619
## as.factor(zcta)55411   2.947904   0.488093   6.040 1.62e-09 ***
## as.factor(zcta)55412   2.354194   0.432437   5.444 5.38e-08 ***
## as.factor(zcta)55413  -0.205577   0.432992  -0.475  0.63496
## as.factor(zcta)55414  -0.421141   0.430667  -0.978  0.32817
## as.factor(zcta)55415   1.152529   0.434889   2.650  0.00806 **
## as.factor(zcta)55416  -0.580212   0.440058  -1.318  0.18738
## as.factor(zcta)55417  -0.347800   0.436608  -0.797  0.42571
## as.factor(zcta)55418  -0.377813   0.435679  -0.867  0.38587
## as.factor(zcta)55419  -0.535217   0.433294  -1.235  0.21679
## as.factor(zcta)55421  -0.015101   0.441480  -0.034  0.97271
## as.factor(zcta)55422  -0.210477   0.441619  -0.477  0.63366
## as.factor(zcta)55423  -0.442733   0.441771  -1.002  0.31629
## as.factor(zcta)55424  -0.601940   0.441756  -1.363  0.17305
## as.factor(zcta)55429   0.104753   0.441785   0.237  0.81258
## as.factor(zcta)55430   0.223424   0.437964   0.510  0.60997
## as.factor(zcta)55450  -0.614245   0.446083  -1.377  0.16856
## as.factor(zcta)55454  -0.109903   0.436008  -0.252  0.80100
## as.factor(zcta)55455  -0.597703   0.441157  -1.355  0.17551
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.884 on 7229 degrees of freedom
##   (38 observations deleted due to missingness)
## Multiple R-squared:  0.03556,    Adjusted R-squared:  0.03022
## F-statistic: 6.663 on 40 and 7229 DF,  p-value: < 2.2e-16
```




```
##       [,1]  [,2]  [,3]  [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## ACF   0.01 -0.01 -0.01 -0.01    0    0    0    0    0     0     0     0     0
## PACF  0.01 -0.01 -0.01  0.00    0    0    0    0    0     0     0     0     0
##       [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF    0.00     0     0     0     0     0     0     0     0     0  0.01  0.01
## PACF  -0.01     0     0     0     0     0     0     0     0     0  0.00  0.01
##       [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF    0.02  0.01  0.01     0  0.01  0.01 -0.01     0     0 -0.01     0     0
## PACF   0.02  0.01  0.01     0  0.01  0.01 -0.01     0     0 -0.01     0     0
##       [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF       0     0     0     0     0  0.02     0  0.01     0     0  0.01     0
## PACF      0     0     0     0     0  0.02     0  0.01     0     0  0.01     0
##       [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61]
## ACF   -0.01     0     0     0  0.01  0.01     0 -0.01 -0.01  0.01     0     0
## PACF  -0.01     0     0     0  0.01  0.01     0  0.00 -0.01  0.01     0     0
##       [,62] [,63] [,64] [,65] [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73]
## ACF       0     0     0  0.00     0     0  0.01     0 -0.01  0.01     0  0.01
## PACF      0     0     0  0.01     0     0  0.01     0 -0.01  0.01     0  0.01
##       [,74] [,75] [,76] [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85]
## ACF       0  0.01     0     0     0     0     0 -0.01 -0.01  0.01     0     0
## PACF      0  0.01     0     0     0     0     0 -0.01 -0.01  0.01     0     0
##       [,86] [,87] [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## ACF    0.01  0.00     0     0     0     0  0.01     0     0 -0.01     0
## PACF   0.01 -0.01     0     0     0     0  0.01     0     0 -0.01     0

##
```

```
## Call:
## lm(formula = assault_incid_c ~ t + state_of_emerg + stay_at_home +
##     post_floyd + post_floyd_3 + tmax_f + snow_in + precip_in +
##     dark_before_12 + school + as.factor(zcta) + post_floyd:as.factor(zcta) +
##     post_floyd_3:as.factor(zcta), data = panel)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -10.790  -0.589  -0.269   0.004 263.627
##
## Coefficients:
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       6.896e-01  8.441e-01   0.817  0.41400
## t                                 2.243e-03  9.952e-04   2.254  0.02426 *
## state_of_emerg                   -5.298e-01  5.652e-01  -0.937  0.34862
## stay_at_home                      2.300e-01  5.813e-01   0.396  0.69232
## post_floyd                       -5.560e-01  1.438e+00  -0.387  0.69894
## post_floyd_3                      3.399e-01  1.741e+00   0.195  0.84523
## tmax_f                            2.877e-03  5.313e-03   0.541  0.58819
## snow_in                          -8.495e-02  1.697e-01  -0.500  0.61679
## precip_in                        -1.840e-01  5.548e-01  -0.332  0.74012
## dark_before_12                   -8.024e-02  9.105e-02  -0.881  0.37821
## school                           -1.522e-01  2.090e-01  -0.728  0.46649
## as.factor(zcta)55402              2.301e+00  4.550e-01   5.057 4.37e-07 ***
## as.factor(zcta)55403             -1.105e-01  4.550e-01  -0.243  0.80811
## as.factor(zcta)55404              4.278e-01  4.550e-01   0.940  0.34719
## as.factor(zcta)55405             -2.036e-01  4.550e-01  -0.447  0.65464
## as.factor(zcta)55406             -2.168e-01  4.550e-01  -0.477  0.63369
## as.factor(zcta)55407             -6.147e-02  4.550e-01  -0.135  0.89254
## as.factor(zcta)55408             -3.636e-01  4.550e-01  -0.799  0.42426
## as.factor(zcta)55409             -2.695e-01  4.550e-01  -0.592  0.55372
## as.factor(zcta)55410             -4.661e-01  4.550e-01  -1.024  0.30569
## as.factor(zcta)55411              2.256e+00  4.550e-01   4.959 7.25e-07 ***
## as.factor(zcta)55412              1.964e+00  4.550e-01   4.317 1.60e-05 ***
## as.factor(zcta)55413             -1.900e-01  4.550e-01  -0.418  0.67631
## as.factor(zcta)55414             -4.043e-01  4.550e-01  -0.889  0.37426
## as.factor(zcta)55415              8.710e-01  4.550e-01   1.914  0.05565 .
## as.factor(zcta)55416             -5.031e-01  4.550e-01  -1.106  0.26888
## as.factor(zcta)55417             -3.153e-01  4.550e-01  -0.693  0.48838
## as.factor(zcta)55418             -3.157e-01  4.550e-01  -0.694  0.48780
## as.factor(zcta)55419             -4.831e-01  4.550e-01  -1.062  0.28843
## as.factor(zcta)55421              2.839e-02  4.550e-01   0.062  0.95025
## as.factor(zcta)55422             -1.887e-01  4.550e-01  -0.415  0.67830
## as.factor(zcta)55423             -3.856e-01  4.550e-01  -0.848  0.39674
## as.factor(zcta)55424             -5.303e-01  4.550e-01  -1.165  0.24393
## as.factor(zcta)55429              2.157e-02  4.550e-01   0.047  0.96220
## as.factor(zcta)55430              1.214e-01  4.550e-01   0.267  0.78963
## as.factor(zcta)55450             -5.414e-01  4.602e-01  -1.176  0.23951
## as.factor(zcta)55454             -3.370e-02  4.550e-01  -0.074  0.94096
## as.factor(zcta)55455             -5.303e-01  4.550e-01  -1.165  0.24393
## post_floyd:as.factor(zcta)55402  -2.301e+00  1.896e+00  -1.214  0.22488
## post_floyd:as.factor(zcta)55403   9.617e-01  1.896e+00   0.507  0.61197
## post_floyd:as.factor(zcta)55404   4.076e+00  1.896e+00   2.150  0.03159 *
## post_floyd:as.factor(zcta)55405   2.444e+00  1.896e+00   1.289  0.19739
```

```
## post_floyd:as.factor(zcta)55406    6.425e-01  1.896e+00   0.339  0.73468
## post_floyd:as.factor(zcta)55407    1.107e+00  1.896e+00   0.584  0.55917
## post_floyd:as.factor(zcta)55408    8.138e-01  1.896e+00   0.429  0.66772
## post_floyd:as.factor(zcta)55409    2.695e-01  1.896e+00   0.142  0.88697
## post_floyd:as.factor(zcta)55410    4.661e-01  1.896e+00   0.246  0.80578
## post_floyd:as.factor(zcta)55411    8.509e+00  1.896e+00   4.489 7.27e-06 ***
## post_floyd:as.factor(zcta)55412    4.383e+00  1.896e+00   2.312  0.02080 *
## post_floyd:as.factor(zcta)55413    1.192e+00  1.896e+00   0.629  0.52961
## post_floyd:as.factor(zcta)55414    1.001e+00  1.896e+00   0.528  0.59756
## post_floyd:as.factor(zcta)55415    5.063e+00  1.896e+00   2.671  0.00759 **
## post_floyd:as.factor(zcta)55416    5.031e-01  1.896e+00   0.265  0.79071
## post_floyd:as.factor(zcta)55417    1.390e+00  1.896e+00   0.733  0.46354
## post_floyd:as.factor(zcta)55418    7.871e-01  1.896e+00   0.415  0.67800
## post_floyd:as.factor(zcta)55419    9.939e-01  1.896e+00   0.524  0.60009
## post_floyd:as.factor(zcta)55421    1.221e+00  1.896e+00   0.644  0.51949
## post_floyd:as.factor(zcta)55422    1.146e+00  1.896e+00   0.605  0.54540
## post_floyd:as.factor(zcta)55423    9.760e-01  1.896e+00   0.515  0.60669
## post_floyd:as.factor(zcta)55424    5.303e-01  1.896e+00   0.280  0.77971
## post_floyd:as.factor(zcta)55429    1.259e+00  1.896e+00   0.664  0.50678
## post_floyd:as.factor(zcta)55430    3.680e+00  1.896e+00   1.941  0.05225 .
## post_floyd:as.factor(zcta)55450    5.414e-01  1.897e+00   0.285  0.77536
## post_floyd:as.factor(zcta)55454    7.463e-01  1.896e+00   0.394  0.69384
## post_floyd:as.factor(zcta)55455    5.303e-01  1.896e+00   0.280  0.77971
## post_floyd_3:as.factor(zcta)55402  6.514e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55403  1.419e-01  2.454e+00   0.058  0.95390
## post_floyd_3:as.factor(zcta)55404 -2.237e+00  2.454e+00  -0.912  0.36196
## post_floyd_3:as.factor(zcta)55405 -1.892e+00  2.454e+00  -0.771  0.44074
## post_floyd_3:as.factor(zcta)55406 -2.601e-01  2.454e+00  -0.106  0.91558
## post_floyd_3:as.factor(zcta)55407 -2.324e-01  2.454e+00  -0.095  0.92454
## post_floyd_3:as.factor(zcta)55408  7.504e-02  2.454e+00   0.031  0.97561
## post_floyd_3:as.factor(zcta)55409  5.140e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55410  5.021e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55411 -5.421e+00  2.454e+00  -2.209  0.02718 *
## post_floyd_3:as.factor(zcta)55412 -1.411e+00  2.454e+00  -0.575  0.56540
## post_floyd_3:as.factor(zcta)55413 -2.226e-01  2.454e+00  -0.091  0.92772
## post_floyd_3:as.factor(zcta)55414 -5.965e-01  2.454e+00  -0.243  0.80794
## post_floyd_3:as.factor(zcta)55415 -3.626e+00  2.454e+00  -1.478  0.13949
## post_floyd_3:as.factor(zcta)55416  5.801e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55417 -1.074e+00  2.454e+00  -0.438  0.66150
## post_floyd_3:as.factor(zcta)55418 -1.048e-01  2.454e+00  -0.043  0.96595
## post_floyd_3:as.factor(zcta)55419 -5.108e-01  2.454e+00  -0.208  0.83509
## post_floyd_3:as.factor(zcta)55421 -8.608e-01  2.454e+00  -0.351  0.72574
## post_floyd_3:as.factor(zcta)55422 -2.660e-02  2.454e+00  -0.011  0.99135
## post_floyd_3:as.factor(zcta)55423 -5.903e-01  2.454e+00  -0.241  0.80989
## post_floyd_3:as.factor(zcta)55424  5.047e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55429  9.103e-01  2.454e+00   0.371  0.71065
## post_floyd_3:as.factor(zcta)55430 -3.309e+00  2.454e+00  -1.349  0.17753
## post_floyd_3:as.factor(zcta)55450  5.857e-14  2.454e+00   0.000  1.00000
## post_floyd_3:as.factor(zcta)55454 -7.126e-01  2.454e+00  -0.290  0.77151
## post_floyd_3:as.factor(zcta)55455  6.736e-14  2.454e+00   0.000  1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.869 on 7206 degrees of freedom
```

```
##   (10 observations deleted due to missingness)
## Multiple R-squared:  0.04495,    Adjusted R-squared:  0.03289
## F-statistic: 3.727 on 91 and 7206 DF,  p-value: < 2.2e-16
```

```
stargazer(ts_ar1_pol, fe_full_model,
          title = "Interrupted Time Series Models of Firearm Assault Injuries",
          covariate.labels = c("T","COVID - State of Emergency", "COVID - Stay at Home",
                               "Post-Killing", "Post-Killing 3 Months",
                               "MPD Use of Force t-1", "MPD Stops t-1",
                               "MPD Officer Involved Shootings t-1",
                               "AR(1)"),
          dep.var.caption = "Firearm Assault Injuries",
          dep.var.labels = "Rate per 1,000",
          column.labels = c("Week-Level", "ZCTA-Week-Level"),
          model.numbers = TRUE,
          single.row = TRUE,
          align = T,
          omit = c("zcta", "tmax_f", "snow_in","precip_in","dark_before_12","school"),
          omit.stat = "adj.rsq",
          star.cutoffs = c(.05, .01, .001), star.char = c("*","**","***"),
          add.lines = list(c("ZCTA FE", "No", "Yes")),
          notes.label = "Models include controls for seasonality.")
```

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
% Date and time: Mon, Mar 07, 2022 - 4:36:30 PM % Requires LaTeX packages: dcolumn

Table 1: Interrupted Time Series Models of Firearm Assault Injuries

| | Firearm Assault Injuries | |
|---|---|---|
| | Rate per 1,000 | |
| | Week-Level | ZCTA-Week-Level |
| | (1) | (2) |
| T | 0.00000 (0.00000) | 0.002* (0.001) |
| COVID - State of Emergency | −0.003 (0.003) | −0.525 (0.569) |
| COVID - Stay at Home | 0.003 (0.003) | 0.221 (0.583) |
| Post-Killing | 0.012*** (0.003) | 0.974 (0.581) |
| Post-Killing 3 Months | −0.005** (0.002) | −0.345 (0.363) |
| MPD Use of Force t-1 | −0.009 (0.008) | −0.051* (0.023) |
| MPD Stops t-1 | 0.001 (0.0005) | 0.002 (0.003) |
| MPD Officer Involved Shootings t-1 | −0.155 (0.223) | −0.294 (0.432) |
| AR(1) | 0.183** (0.062) | |
| Constant | 0.005 (0.004) | 0.671 (0.845) |
| ZCTA FE | *No* | *Yes* |
| Observations | 260 | 7,270 |
| $R^2$ | 0.384 | 0.036 |
| Residual Std. Error | 0.004 (df = 245) | 4.884 (df = 7229) |
| F Statistic | 10.889*** (df = 14; 245) | 6.663*** (df = 40; 7229) |
| Models include controls for seasonality. | | *p<0.05; **p<0.01; ***p<0.001 |

```r
#maps of post_floyd and post_floyd_3 coefficients by zip - colored divergently
coef <- broom::tidy(fe_int_model$coefficients) %>%
  filter(str_detect(names, "post_floyd")) %>%
  mutate(period = ifelse(str_detect(names, "post_floyd_3"), "3+ Months Post-Killing", "0-3 Months Post-K
         main_effect = ifelse(period=="3+ Months Post-Killing", round(0.3399083,2), round(-0.5604477,2))
         zcta = as.numeric(str_sub(names, -5)),
         zcta = as.numeric(ifelse(is.na(zcta), "55401", zcta)),
         interaction_effect = ifelse(zcta=="55401", 0, round(x,2)),
         coef = main_effect+interaction_effect) %>%
  select(zcta, period, coef, main_effect, interaction_effect) %>%
  arrange(zcta, period)
```

```
## Warning: 'tidy.numeric' is deprecated.
## See help("Deprecated")
```

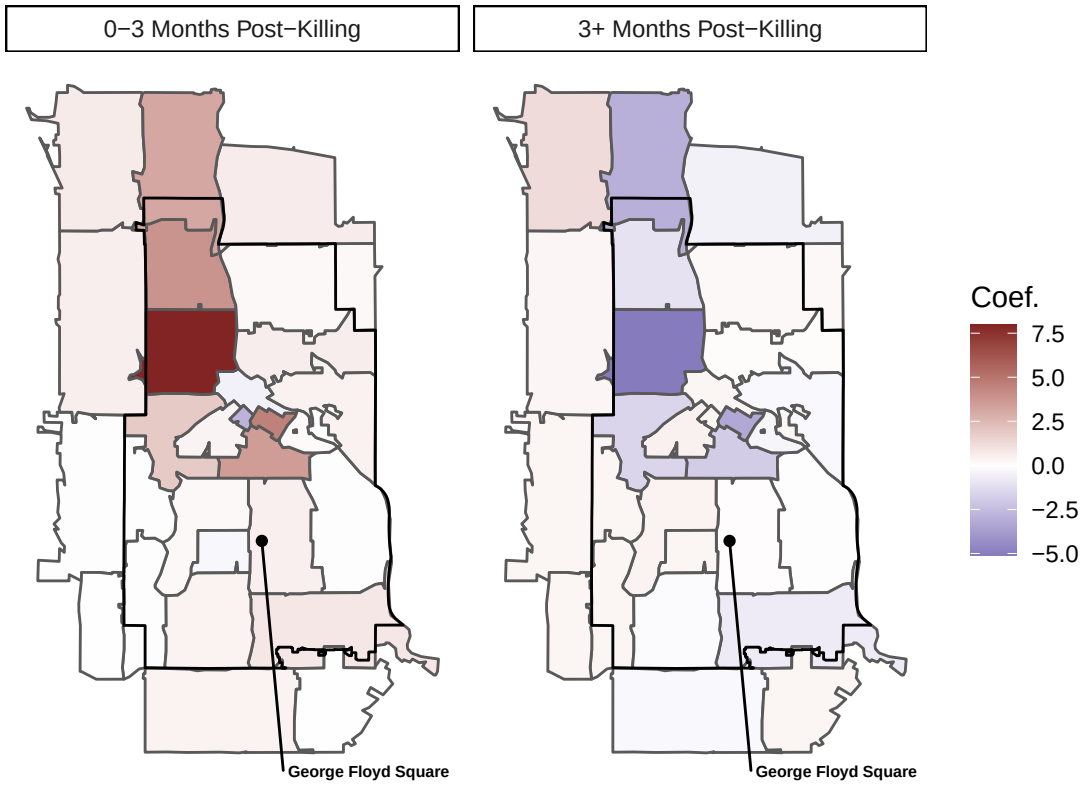
```
## Warning: `data_frame()` was deprecated in tibble 1.1.0.
## Please use `tibble()` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was generated.
```

```
## Warning in mask$eval_all_mutate(quo): NAs introduced by coercion
```

```r
#creating period rows in other spatial layers
coef_zip_level <- zip_level %>%
  filter(period!="Pre-Killing") %>%
  left_join(coef, by = c("zcta", "period"))
coef_gfs <- gfs
coef_gfs[2,] <- gfs[1,]
coef_gfs$period <- c("3+ Months Post-Killing", "0-3 Months Post-Killing")
coef_mpls <- mpls
coef_mpls[2,] <- mpls[1,]
coef_mpls$period <- c("3+ Months Post-Killing", "0-3 Months Post-Killing")


ggplot() +
  geom_sf(data = coef_zip_level, aes(geometry = geometry, fill = coef)) +
  geom_sf(data = mpls, aes(geometry = geometry), color = "black", alpha = 0)+
  geom_sf(data = coef_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)+
  scale_fill_gradient2(trans="reverse")+
  facet_wrap(~period)+
  labs(title = "Figure 3: Treatment Effects by ZCTA",
       fill = "Coef.")+
  theme(axis.text = 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"))+
  guides(fill = guide_colorbar(reverse = TRUE))
```

Figure 3: Treatment Effects by ZCTA

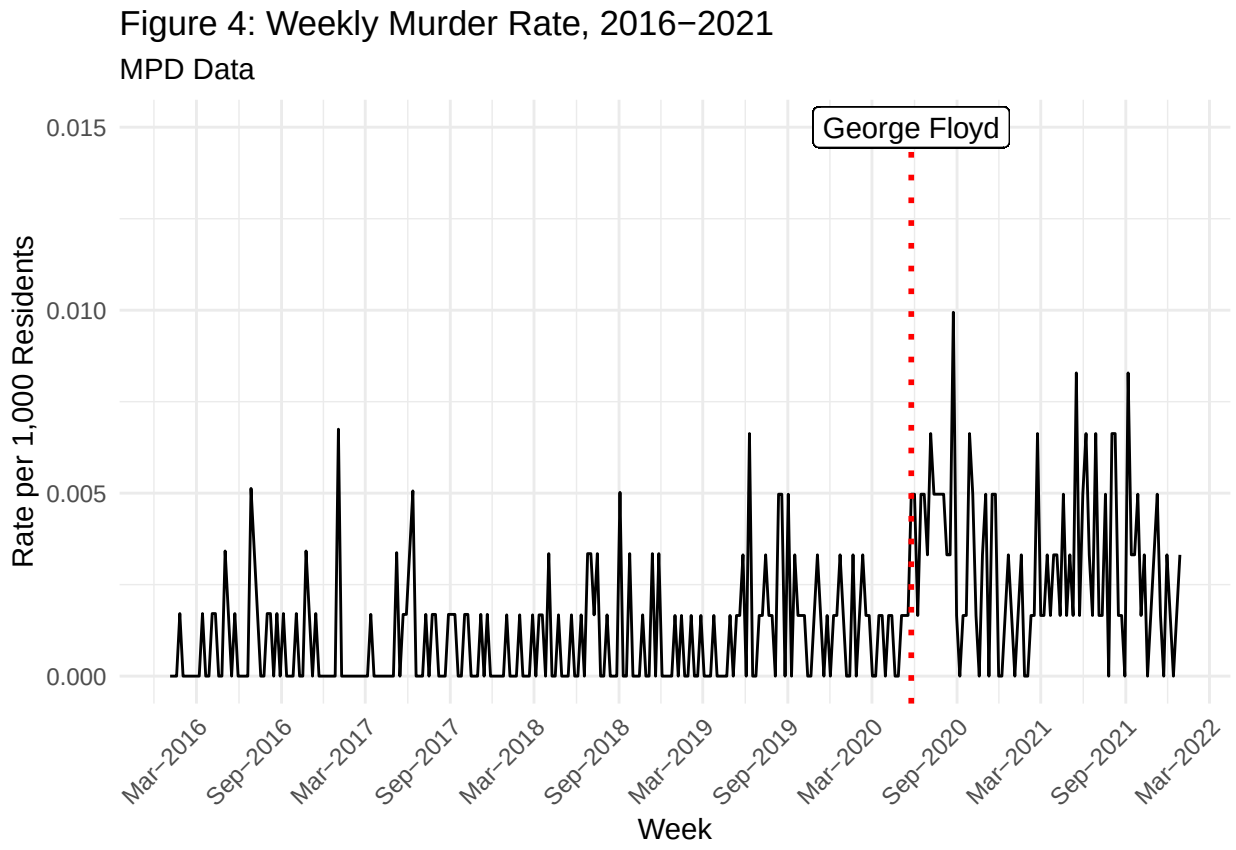



## MPD Murders: Figures 4 and 5

```
#pre-pims
mpd_2016 <- read_csv("Data/Police_Incidents_2016.csv")
mpd_2017 <- read_csv("Data/Police_Incidents_2017.csv")
mpd_2018a <- read_csv("Data/Police_Incidents_2018.csv")

#pims
mpd_2018b <- read_csv("Data/Police_Incidents_2018_PIMS.csv")
mpd_2019 <- read_csv("Data/Police_Incidents_2019.csv")
mpd_2020 <- read_csv("Data/Police_Incidents_2020.csv")
mpd_2021 <- read_csv("Data/Police_Incidents_2021.csv")

pre_pims_base <- mpd_2016 %>%
  rbind(mpd_2017) %>%
```

```
  rbind(mpd_2018a) %>%
  rename(reportedDate = ReportedDate,
         centerLong = Long,
         centerLat = Lat) %>%
  select(FID, centerLong, centerLat, Offense, reportedDate) %>%
  rename(OBJECTID = FID,
         X = centerLong,
         Y = centerLat,
         offense = Offense)

post_pims_base <- mpd_2018b %>%
  rbind(mpd_2019) %>%
  rbind(mpd_2020) %>%
  rbind(mpd_2021) %>%
  select(OBJECTID, X, Y, offense, reportedDate)

mpd <- pre_pims_base %>%
  rbind(post_pims_base)

mpd_series <- mpd %>%
  mutate(date=ymd_hms(reportedDate),
         year=isoyear(date),
          week=isoweek(date)) %>%
  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(offense=="MURDR" & zcta %in% zcta_universe) %>%
  group_by(year, week, .drop=F) %>%
  tally(name = "murder") %>%
  arrange(year, week) %>%
  filter(year <= 2021 & year >= 2016) %>%
  ungroup() %>%
  complete(year, week = 1:52, fill = list(murder = 0))

mpls_pops_year <- series %>%
  group_by(year) %>%
  summarize(total_pop = mean(total_pop, na.rm = T)) %>%
  add_row(year = 2021, total_pop = 603465)


mpd_series <- mpd_series %>%
  left_join(mpls_pops_year, by = "year") %>%
  mutate(murder_rate = (murder/total_pop)*1000,
         begin_date = ISOweek2date(paste(year, paste0("W", sprintf("%02d", week)), 1,sep = "-")),
         end_date = begin_date+weeks(1)-days(1))

ggplot(mpd_series)+
  geom_line(aes(x=begin_date, y=murder_rate))+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_vline(xintercept=mpd_series$begin_date[mpd_series$year==2020 & mpd_series$week==isoweek(date("202
             linetype="dotted", color="red", size=1)+
  geom_label(aes(x=mpd_series$begin_date[mpd_series$year==2020 & mpd_series$week==isoweek(date("2020-05-
```

```
                y=0.0150),
            label = "George Floyd", show.legend = FALSE)+
  scale_y_continuous(limits = c(0,.015))+
  labs(title = "Figure 4: Weekly Murder Rate, 2016-2021",
       subtitle = "MPD Data",
       x = "Week",
       y = "Rate per 1,000 Residents")+
  theme_minimal()+
    theme(axis.text.x=element_text(angle=45, hjust=1))
```

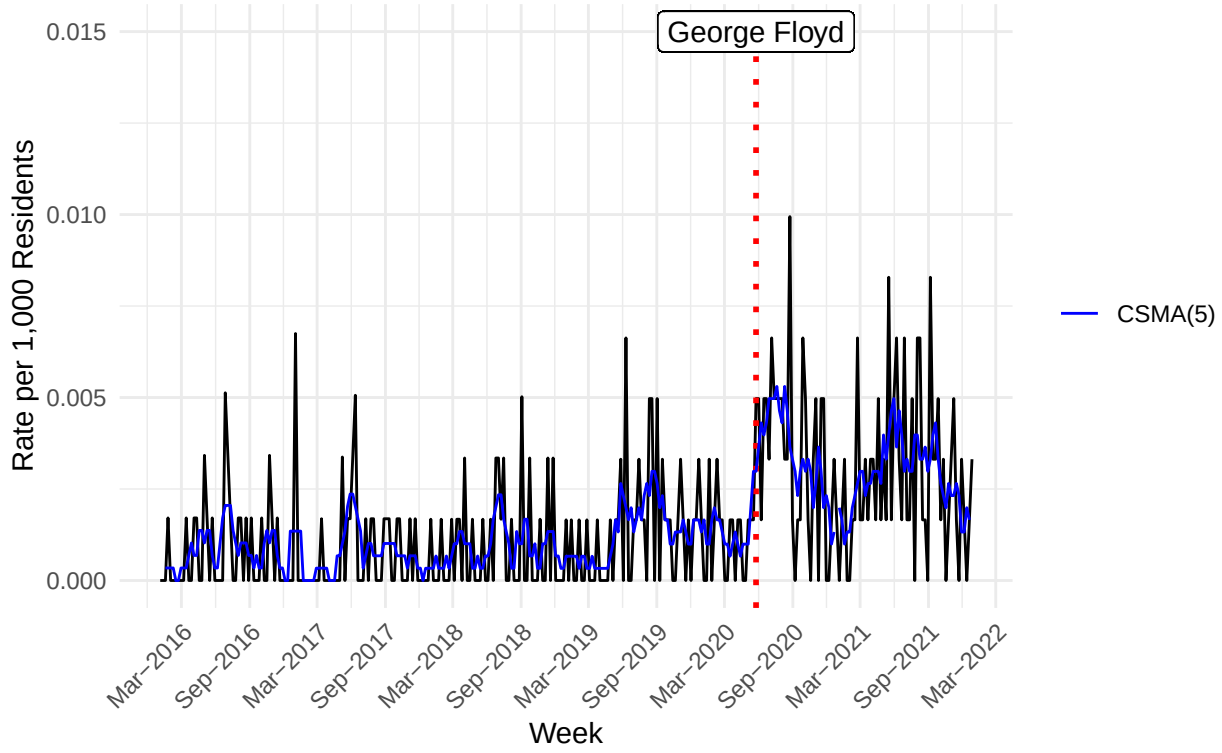



```
mpd_series <- mpd_series %>%
  mutate(csma = forecast::ma(murder_rate, order=5,centre=TRUE),
         tsma = TTR::SMA(murder_rate, n=5))

ggplot(mpd_series)+
  geom_line(aes(x=begin_date, y=murder_rate))+
  scale_x_date(date_labels = "%b-%Y", date_breaks = "6 months")+
  geom_vline(xintercept=mpd_series$begin_date[mpd_series$year==2020 & mpd_series$week==isoweek(date("202
             linetype="dotted", color="red", size=1)+
  geom_label(aes(x=mpd_series$begin_date[mpd_series$year==2020 & mpd_series$week==isoweek(date("2020-05-
                y=0.0150),
            label = "George Floyd", show.legend = FALSE)+
  scale_y_continuous(limits = c(0,.015))+
  labs(title = "Figure 4: Weekly Murder Rate, 2016-2021",
       subtitle = "MPD Data",
```

```
       x = "Week",
       y = "Rate per 1,000 Residents",
       color = NULL)+
  theme_minimal()+
  theme(axis.text.x=element_text(angle=45, hjust=1)) +
  geom_line(aes(x=begin_date, y=csma, color = "CSMA(5)"))+
  #geom_line(aes(x=begin_date, y=tsma, color = "TSMA(5)"))+
  #geom_ma(aes(x = begin_date, y = murder_rate, color = "MA4"), ma_fun = SMA, n = 4)
  scale_color_manual(values = c("blue", "green"))
```

Figure 4: Weekly Murder Rate, 2016−2021

MPD Data




```
mpls_pops_zcta <- panel %>%
  select(zcta, year, weekofyr, total_pop) %>%
  st_drop_geometry() %>%
  ungroup() %>%
  complete(zcta, year = 2016:2021, weekofyr = 1:52) %>%
  arrange(zcta, year, weekofyr) %>%
  mutate(total_pop = ifelse(is.na(total_pop), na_locf(total_pop), total_pop)) %>%
  group_by(zcta) %>%
  summarize(total_pop = mean(total_pop, na.rm = T))


mpd_zip <- mpd %>%
  mutate(date=ymd_hms(reportedDate),
         year=isoyear(date),
          week=isoweek(date)) %>%
```

```
  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(offense=="MURDR" & zcta %in% zcta_universe) %>%
  group_by(year, week, zcta, .drop=F) %>%
  tally(name = "murder") %>%
  arrange(zcta, year, week) %>%
  ungroup() %>%
  complete(year, week=1:52, zcta=zcta_universe, fill = list(murder = 0)) %>%
  filter(year <= 2021 & year >= 2016) %>%
  mutate(begin_date = ISOweek2date(paste(year, paste0("W", sprintf("%02d", week)), 1,sep = "-")),
         end_date = begin_date+weeks(1)-days(1),
         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)),
         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"))) %>%
  left_join(mpls_pops_zcta, by = "zcta") %>%
  group_by(period, zcta, .drop=F) %>%
  summarize(murder = mean(murder, na.rm = T),
            total_pop = mean(total_pop, an.rm = T)) %>%
  left_join(zcta, by = "zcta") %>%
  mutate(murder_rate = (murder/total_pop)*1000)
```

```
## `summarise()` has grouped output by 'period'. You can override using the
## `.groups` argument.
```

```
ggplot() +
  geom_sf(data = mpd_zip, aes(geometry = geometry, fill = murder_rate)) +
  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 5: Murder Rates by ZCTA and Period",
       subtitle = "MPD Data",
       fill = "Murder Rate/1,000")+
  theme(axis.text = 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 5: Murder Rates by ZCTA and Period

*MPD Data*