Take-home Exercise 1

Analysing and Visualising Spatio-temporal Patterns of COVID-19 in DKI Jakarta, Indonesia

AUTHOR

Lye Jia Wei

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1. Introduction

Since late December 2019, an outbreak of a novel coronavirus disease (COVID-19; previously known as 2019-nCoV) was reported in Wuhan, China, which had subsequently affected 210 countries worldwide. In general, COVID-19 is an acute resolved disease but it can also be deadly, with a 2% case fatality rate.

The COVID-19 pandemic in Indonesia is part of the ongoing worldwide pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The virus was confirmed to have reached Indonesia on March 2, 2020. It started with two cases in March. As of July 31 2021, there had been 3,409,658 cumulative confirmed cases of COVID-19 in Indonesia and 94,119 reported cumulative deaths. All cases were spread in 34 provinces in Indonesia. Among all the provinces, DKI Jakarta (Indonesian: Daerah Khusus Ibukota Jakarta and in English: Special Capital Region of Jakarta) contributed close to 24% of the cumulative confirmed cases.

2. Problem Statement

Given that the cumulative confirmed cases were not evenly distributed within DKI Jakarta, this geospatial analysis aim to

- Reveal the spatial-temporal patterns of COVID-19 case in DKI Jakarta
- Find out sub-districts with relatively higher number of confirmed cases
- Identify trends of COVID-19 case in the sub-districts and how they change over time.

3. Data

In this analysis, the following dataset were used:

Data	Description	Format	Source
Jakarta COVID-19 Data	Daily COVID-19 data of DKI Jakarta month between March 2020 to July 2021	XLSX	Open Data Covid-19 Provinsi DKI
DKI Jarkata shapefile	Jakarta sub-district	Shapefile	Indonesia Geospatial Data

Note: Jakarta COVID-19 data file for last day of each month is used with the exception of missing file for 31 January 2021, hence 30th January 2021 data set is used

4. Getting Started

In this exercise, the key R package use is tmap package in R. Beside tmap package, seven other R packages will be used. They are:

- sf for handling geospatial data,
- tidyverse for subsetting and transforming data
- ReadXL for importing XLSX file
- plotly for data visualization
- dplyr for data maniupulation
- plyr for splitting, applying and combining Data
- tmap to produce thematic map
- spdep to create spatial weights matrix objects

```
packages <- c('sf','tidyverse','readxl','plotly','dplyr',
'plyr','tmap','spdep')
for (p in packages) {
  if (!require(p, character.only = T
)) {
    install.packages(p)
  }
  library(p, character.only = T)
}
```

5 Data Import

5.1 Importing Geospatial Data Into R

Import the data and examine the content of the data set.

-Data will first be imported as an sf object to facilitate data pre-processing and initial analysis, then converted to sp class in the later part of the analysis.

```
DKI_Jakarta = st_read ( dsn= "data/geospatial",layer=
"BATAS_DESA_DESEMBER_2019_DUKCAPIL_DKI_JAKARTA")
```

```
Reading layer `BATAS_DESA_DESEMBER_2019_DUKCAPIL_DKI_JAKARTA' from data source `C:\Users\User\Desktop
  using driver `ESRI Shapefile'
Simple feature collection with 269 features and 161 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: 106.3831 ymin: -6.370815 xmax: 106.9728 ymax: -5.184322
Geodetic CRS:  WGS 84
```

The message above reveals that the geospatial objects are multipolygon features. There are a total of 269 multipolygon features and 161 fields in DKI_Jakarta simple feature data frame. DKI is in WGS84 projected coordinates systems.

###5.2 Importing Attribute Data Into R

Next, we will import monthly Covid-19 data XLSX file from a folder into RStudio and save it into an R dataframe called Covid_DF.

5.2.1 READING XLSX FILE

The task will be performed by using lapply() in combination with read_xlsx() function to identify all the xlsx file and then applying a function to transform the file in the File_List as shown in the code chunk below. We will also be adding 'Date' field to extractthe date from file name in the subsequent step.

```
File_List <- list.files( path =
"C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-
        1/data/aspatial"
, pattern = "*.xlsx" , full.names = T )

DF_List <- lapply ( seq_along( File_List) , function (
x ) transform( read_xlsx( File_List[ x ]
) , Date = File_List[ x ] ) )
```

5.2.2 CREATING DATAFRAME

We will then convert the DF_List into dataframe called Covid_DF using the ldpy function. This will be a temporary dataframe which we will then carry out data cleaning in the later step.

```
Covid_DF <- ldply(DF_List, data.frame)
```

6.Data Extraction, Wrangling and Integration

6.1 Geospatial Data

6.1.1 DATA CLEANING

First, we have to ensure that spatial data used for analysis has no invalid geometries.

```
length(which(st_is_valid(DKI_Jakarta) == FALSE
))
```

```
[1] 0
```

- There are no invalid geometries in the data that needs to be handled.

Check the geospatial data for missing values, as missing values can impact future calculations.

```
DKI_Jakarta[rowSums(is.na(DKI_Jakarta))!=
0,]
```

```
Simple feature collection with 2 features and 161 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: 106.8412 ymin: -6.154036 xmax: 106.8612 ymax: -6.144973
Geodetic CRS:  WGS 84
    OBJECT_ID KODE_DESA             DESA   KODE    PROVINSI KAB_KOTA
243     25645  31888888     DANAU SUNTER 318888 DKI JAKARTA     <NA>
244     25646  31888888 DANAU SUNTER DLL 318888 DKI JAKARTA     <NA>
    KECAMATAN DESA_KELUR JUMLAH_PEN JUMLAH_KK LUAS_WILAY KEPADATAN
243      <NA>       <NA>          0         0          0         0
244      <NA>       <NA>          0         0          0         0
    PERPINDAHA JUMLAH_MEN PERUBAHAN WAJIB_KTP SILAM KRISTEN KHATOLIK
243          0          0         0         0     0       0        0
244          0          0         0         0     0       0        0
    HINDU BUDHA KONGHUCU KEPERCAYAA PRIA WANITA BELUM_KAWI KAWIN
243     0     0        0          0    0      0          0     0
244     0     0        0          0    0      0          0     0
    CERAI_HIDU CERAI_MATI U0 U5 U10 U15 U20 U25 U30 U35 U40 U45 U50
243          0          0  0  0   0   0   0   0   0   0   0   0   0
244          0          0  0  0   0   0   0   0   0   0   0   0   0
    U55 U60 U65 U70 U75 TIDAK_BELU BELUM_TAMA TAMAT_SD SLTP SLTA
243   0   0   0   0   0          0          0        0    0    0
```

```
244  0   0   0   0   0          0          0        0    0    0
    DIPLOMA_I DIPLOMA_II DIPLOMA_IV STRATA_II STRATA_III BELUM_TIDA
243         0          0          0         0          0          0
244         0          0          0         0          0          0
    APARATUR_P TENAGA_PEN WIRASWASTA PERTANIAN NELAYAN AGAMA_DAN
243          0          0          0         0       0         0
244          0          0          0         0       0         0
    PELAJAR_MA TENAGA_KES PENSIUNAN LAINNYA GENERATED KODE_DES_1
243          0          0         0       0      <NA>       <NA>
244          0          0         0       0      <NA>       <NA>
    BELUM_ MENGUR_ PELAJAR_ PENSIUNA_1 PEGAWAI_ TENTARA KEPOLISIAN
243      0       0        0          0        0       0          0

244      0       0        0          0        0       0          0
    PERDAG_ PETANI PETERN_ NELAYAN_1 INDUSTR_ KONSTR_ TRANSP_ KARYAW_
243       0      0       0         0        0       0       0       0
244       0      0       0         0        0       0       0       0
    KARYAW1 KARYAW1_1 KARYAW1_12 BURUH BURUH_ BURUH1 BURUH1_1
243       0         0          0     0      0      0        0
244       0         0          0     0      0      0        0
    PEMBANT_ TUKANG TUKANG_1 TUKANG_12 TUKANG__13 TUKANG__14
243        0      0        0         0          0          0
244        0      0        0         0          0          0
    TUKANG__15 TUKANG__16 TUKANG__17 PENATA PENATA_ PENATA1_1 MEKANIK
243          0          0          0      0       0         0       0
244          0          0          0      0       0         0       0
    SENIMAN_ TABIB PARAJI_ PERANCA_ PENTER_ IMAM_M PENDETA PASTOR
243        0     0       0        0       0      0       0      0
244        0     0       0        0       0      0       0      0
    WARTAWAN USTADZ JURU_M PROMOT ANGGOTA_ ANGGOTA1 ANGGOTA1_1
243        0      0      0      0        0        0          0
244        0      0      0      0        0        0          0
    PRESIDEN WAKIL_PRES ANGGOTA1_2 ANGGOTA1_3 DUTA_B GUBERNUR
243        0          0          0          0      0        0
244        0          0          0          0      0        0
    WAKIL_GUBE BUPATI WAKIL_BUPA WALIKOTA WAKIL_WALI ANGGOTA1_4
243          0      0          0        0          0          0
244          0      0          0        0          0          0
    ANGGOTA1_5 DOSEN GURU PILOT PENGACARA_ NOTARIS ARSITEK AKUNTA_
243          0     0    0     0          0       0       0       0
244          0     0    0     0          0       0       0       0
    KONSUL_ DOKTER BIDAN PERAWAT APOTEK_ PSIKIATER PENYIA_ PENYIA1
243       0      0     0       0       0         0       0       0
244       0      0     0       0       0         0       0       0
    PELAUT PENELITI SOPIR PIALAN PARANORMAL PEDAGA_ PERANG_ KEPALA_
243      0        0     0      0          0       0       0       0
244      0        0     0      0          0       0       0       0
    BIARAW_ WIRASWAST_ LAINNYA_12 LUAS_DESA KODE_DES_3 DESA_KEL_1
243       0          0          0         0       <NA>       <NA>
244       0          0          0         0       <NA>       <NA>
    KODE_12                       geometry
243       0 MULTIPOLYGON (((106.8612 -6...
```

```
244       0 MULTIPOLYGON (((106.8504 -6...
```

- From the output, we can see that object ID 25645 and 25646 has missing value for the column 'KAB_KOTA' and 'KECAMATAN' amongst other column
- 'KODE DESA' format is inconsistent with the other data in the same column

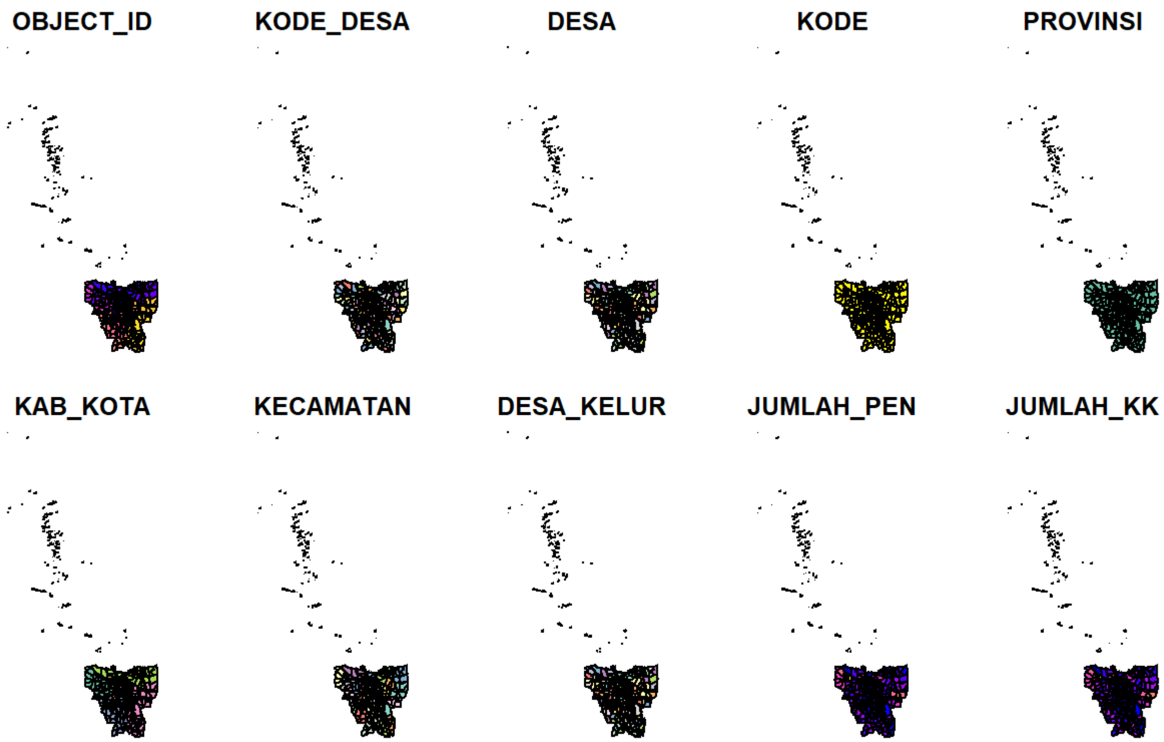
Hence, we will proceed to drop the two rows with the following code chunk

```
DKI_Jakarta <-        na.omit  (        DKI_Jakarta,c        (        "DESA_KELUR")
)
```

6.1.2 PLOTTING THE GEOSPATIAL DATA

Let us now quickly visualize the DKI_Jakarta dataframe

```
plot     (        DKI_Jakarta)
```



From the map, it is evident that DKI_Jakarta consists of outer islands which is not part of our intended study area. We will look into that after we check the projected coordination system.

6.1.3 DEFINE PROJECTION

- The spatial data of Jakarta (Indonesia) is utilised in this analysis.
- Initial data exploration reveals that data is to be projected with the World Geodetic System 1984 datum.

- The corresponding EPSG code is EPSG: 23845.
- The CRS of the data will be checked, then assigned accordingly.
- Unit of measurement will be in metres.

```
st_crs(DKI_Jakarta)
```

```
Coordinate Reference System:
  User input: WGS 84
  wkt:
GEOGCRS["WGS 84",
    DATUM["World Geodetic System 1984",
        ELLIPSOID["WGS 84",6378137,298.257223563,
            LENGTHUNIT["metre",1]]],
    PRIMEM["Greenwich",0,
        ANGLEUNIT["degree",0.0174532925199433]],
    CS[ellipsoidal,2],
        AXIS["latitude",north,
            ORDER[1],
            ANGLEUNIT["degree",0.0174532925199433]],
        AXIS["longitude",east,
            ORDER[2],
            ANGLEUNIT["degree",0.0174532925199433]],
    ID["EPSG",4326]]
```

6.1.6 ASSIGNING A COORDINATE SYSTEM

Although DKI_Jakarta data frame is projected in WGS84 but when we read until the end of the print, it indicates that the EPSG is 4326. This is a wrong EPSG code because the correct EPSG code should be 23845.

In order to assign the correct EPSG code to DKI_Jakarta data frame as well as to set the national projeted coordinates systems of Indonesia whhich is DGN95, st_transform is used as shown in the code chunk below.

```
DKI_Jakarta <- st_transform(DKI_Jakarta, 23845)
```

Let us check the CSR again to ensure that changes are reflected

```
st_crs(DKI_Jakarta)
```

```
Coordinate Reference System:
  User input: EPSG:23845
  wkt:
PROJCRS["DGN95 / Indonesia TM-3 zone 54.1",
    BASEGEOGCRS["DGN95",
        DATUM["Datum Geodesi Nasional 1995"
```

```
    DATUM["Datum Geodesi Nasional 1995",
        ELLIPSOID["WGS 84",6378137,298.257223563,
            LENGTHUNIT["metre",1]]],
    PRIMEM["Greenwich",0,
        ANGLEUNIT["degree",0.0174532925199433]],
    ID["EPSG",4755]],
CONVERSION["Indonesia TM-3 zone 54.1",
    METHOD["Transverse Mercator",
        ID["EPSG",9807]],
    PARAMETER["Latitude of natural origin",0,
        ANGLEUNIT["degree",0.0174532925199433],
        ID["EPSG",8801]],
    PARAMETER["Longitude of natural origin",139.5,
        ANGLEUNIT["degree",0.0174532925199433],
        ID["EPSG",8802]],
    PARAMETER["Scale factor at natural origin",0.9999,
        SCALEUNIT["unity",1],
        ID["EPSG",8805]],
    PARAMETER["False easting",200000,
        LENGTHUNIT["metre",1],
        ID["EPSG",8806]],
    PARAMETER["False northing",1500000,
        LENGTHUNIT["metre",1],
        ID["EPSG",8807]]],
CS[Cartesian,2],
    AXIS["easting (X)",east,
        ORDER[1],
        LENGTHUNIT["metre",1]],
    AXIS["northing (Y)",north,
        ORDER[2],
        LENGTHUNIT["metre",1]],
USAGE[
    SCOPE["Cadastre."],
    AREA["Indonesia - onshore east of 138Â°E."],
    BBOX[-9.19,138,-1.49,141.01]],
ID["EPSG",23845]]
```

- We have successfully assign DGN95:23845 as the projection for the data.

6.1.4 REMOVING OUTER ISLANDS

To exclude all the outer islands from the DKI_Jakarta dataframe, we will plot an interactive map to identify the mainland.

```
tmap_mode(        "view"    )
tm_shape (        DKI_Jakarta)        +
  tm_fill  (        )
```

From the initial exploration, it can be found that Object_ID greater than 25383 consists of the island. Hence, we will proceed to filter them out.

```
DKI_Jakarta <- filter(DKI_Jakarta, OBJECT_ID > 25383)
```

6.1.5 NA, GEOMETRIC VALIDITY CHECKS AND CORRECTION

To check if there are any NA values as a result of data manipulation in the previous step.

```
DKI_Jakarta[rowSums(is.na(DKI_Jakarta)) != 0,]
```

```
Simple feature collection with 0 features and 161 fields
Bounding box:  xmin: NA ymin: NA xmax: NA ymax: NA
Projected CRS: DGN95 / Indonesia TM-3 zone 54.1
  [1] OBJECT_ID  KODE_DESA  DESA       KODE       PROVINSI
  [6] KAB_KOTA   KECAMATAN  DESA_KELUR JUMLAH_PEN JUMLAH_KK
 [11] LUAS_WILAY KEPADATAN  PERPINDAHA JUMLAH_MEN PERUBAHAN
 [16] WAJIB_KTP  SILAM      KRISTEN    KHATOLIK   HINDU
 [21] BUDHA      KONGHUCU   KEPERCAYAA PRIA       WANITA
 [26] BELUM_KAWI KAWIN      CERAI_HIDU CERAI_MATI U0
 [31] U5         U10        U15        U20        U25
 [36] U30        U35        U40        U45        U50
 [41] U55        U60        U65        U70        U75
 [46] TIDAK_BELU BELUM_TAMA TAMAT_SD   SLTP       SLTA
 [51] DIPLOMA_I  DIPLOMA_II DIPLOMA_IV STRATA_II  STRATA_III
 [56] BELUM_TIDA APARATUR_P TENAGA_PEN WIRASWASTA PERTANIAN
 [61] NELAYAN    AGAMA_DAN  PELAJAR_MA TENAGA_KES PENSIUNAN
 [66] LAINNYA    GENERATED  KODE_DES_1 BELUM_     MENGUR_
 [71] PELAJAR_   PENSIUNA_1 PEGAWAI_   TENTARA    KEPOLISIAN
 [76] PERDAG_    PETANI     PETERN_    NELAYAN_1  INDUSTR_
 [81] KONSTR_    TRANSP_    KARYAW_    KARYAW1    KARYAW1_1
 [86] KARYAW1_12 BURUH      BURUH_     BURUH1     BURUH1_1
 [91] PEMBANT_   TUKANG     TUKANG_1   TUKANG_12  TUKANG__13
 [96] TUKANG__14 TUKANG__15 TUKANG__16 TUKANG__17 PENATA
[101] PENATA_    PENATA1_1  MEKANIK    SENIMAN_   TABIB
[106] PARAJI_    PERANCA_   PENTER_    IMAM_M     PENDETA
[111] PASTOR     WARTAWAN   USTADZ     JURU_M     PROMOT
[116] ANGGOTA_   ANGGOTA1   ANGGOTA1_1 PRESIDEN   WAKIL_PRES
[121] ANGGOTA1_2 ANGGOTA1_3 DUTA_B     GUBERNUR   WAKIL_GUBE
[126] BUPATI     WAKIL_BUPA WALIKOTA   WAKIL_WALI ANGGOTA1_4
[131] ANGGOTA1_5 DOSEN      GURU       PILOT      PENGACARA_
[136] NOTARIS    ARSITEK    AKUNTA_    KONSUL_    DOKTER
[141] BIDAN      PERAWAT    APOTEK_    PSIKIATER  PENYIA_
[146] PENYIA1    PELAUT     PENELITI   SOPIR      PIALAN
[151] PARANORMAL PEDAGA_    PERANG_    KEPALA_    BIARAW_
[156] WIRASWAST_ LAINNYA_12 LUAS_DESA  KODE_DES_3 DESA_KEL_1
[161] KODE_12    geometry
<0 rows> (or 0-length row.names)
```

6.1.4 RETAIN THE FIRST NINE FIELDS IN THE DKI JAKARTA SF DATA FRAME

Since we are only interested in the first nine fields of the DKI_Jakarta sf dataframe, we will only retain these columns.

```
DKI_Jakarta <-        DKI_Jakarta[       , 0        :        9        ]
```

6.1.5 TRANSLATING COLUMN NAME FOR DKI_JAKARTA TO ENGLISH

For convenience and ease of comprehension, we will translate the DKI_Jakarta column names to English.

```
DKI_Jakarta <-        DKI_Jakarta %>%
  dplyr    ::       rename    (
    Total_Population=        JUMLAH_PEN, Sub_District=        DESA_KELUR, District=
KECAMATAN,
    City=        KAB_KOTA , Province=        PROVINSI , Village=        DESA     , ID=
KODE      ,
    Village_Code=        KODE_DESA, Object_ID=        OBJECT_ID
    )
```

6.2 Aspatial Data

6.2.1 UNDERSTANDING TEMP_COVID_DF

To better understand the data structure of Temp_Covid_DF, we will inspect it quickly.

```
head     (        Covid_DF )
```

```
      ID_KEL Nama_provinsi     nama_kota nama_kecamatan
1       <NA>          <NA>          <NA>           <NA>
2 3172051003   DKI JAKARTA JAKARTA UTARA     PADEMANGAN
3 3173041007   DKI JAKARTA JAKARTA BARAT        TAMBORA
4 3175041005   DKI JAKARTA JAKARTA TIMUR    KRAMAT JATI
5 3175031003   DKI JAKARTA JAKARTA TIMUR     JATINEGARA
6 3175101006   DKI JAKARTA JAKARTA TIMUR       CIPAYUNG
  nama_kelurahan SUSPEK Perawatan.RS...7 Isolasi.di.Rumah...8
1          TOTAL 717950              197                28717
2          ANCOL    N/A              N/A                  N/A
3          ANGKE    N/A              N/A                  N/A
4    BALE KAMBANG    N/A              N/A                  N/A
5     BALI MESTER    N/A              N/A                  N/A
6     BAMBU APUS    N/A              N/A                  N/A
  Suspek.Meninggal Selesai.Isolasi...10 PROBABLE Perawatan.RS...12
1             2311               686725     7476                95
2              N/A                  N/A      N/A               N/A
3              N/A                  N/A      N/A               N/A
4              N/A                  N/A      N/A               N/A
5              N/A                  N/A      N/A               N/A
```

```
6             N/A                 N/A      N/A              N/A
  Isolasi.di.Rumah...13 Probable.Meninggal Selesai.Isolasi...15
1                     0               5333                 2048
2                   N/A                N/A                  N/A
3                   N/A                N/A                  N/A
4                   N/A                N/A                  N/A
5                   N/A                N/A                  N/A
6                   N/A                N/A                  N/A
  PELAKU.PERJALANAN Perawatan.RS...17 Isolasi.di.Rumah...18
1              4452                 0                     3
2               N/A               N/A                   N/A
3               N/A               N/A                   N/A
4               N/A               N/A                   N/A
5               N/A               N/A                   N/A
6               N/A               N/A                   N/A
  Selesai.Isolasi...19 KONTAK.ERAT Perawatan.RS...21
1                 4449      886591                 0
2                  N/A         N/A               N/A
3                  N/A         N/A               N/A
4                  N/A         N/A               N/A
5                  N/A         N/A               N/A
6                  N/A         N/A               N/A
  Isolasi.di.Rumah...22 Selesai.Isolasi...23 DISCARDED
1                 44028               842563     17463
2                   N/A                  N/A       N/A
3                   N/A                  N/A       N/A
4                   N/A                  N/A       N/A
5                   N/A                  N/A       N/A
6                   N/A                  N/A       N/A
  Isolasi.di.Rumah...25 Meninggal...26 Selesai.Isolasi...27 POSITIF
1                     0              1                17462  339735
2                   N/A            N/A                  N/A     834
3                   N/A            N/A                  N/A     617
4                   N/A            N/A                  N/A     755
5                   N/A            N/A                  N/A     358
6                   N/A            N/A                  N/A     870
  Dirawat Sembuh Meninggal...31 Self.Isolation Keterangan
1    4425 323892           5478           5940         NA
2       8    808              9              9         NA
3      23    572              8             14         NA
4       8    698             15             34         NA
5       4    344              8              2         NA
6      19    816             13             22         NA

1 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
2 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
3 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
4 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
5 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
6 C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_posts/2021-08-30-take-home-exercise-1/data/aspa
  ID_KEL...1 ID_KEL...2 ODP Proses.Pemantauan Selesai.Pemantauan PDP
```

```
1       <NA>       <NA>  NA                 NA                 NA  NA
2       <NA>       <NA>  NA                 NA                 NA  NA
3       <NA>       <NA>  NA                 NA                 NA  NA
4       <NA>       <NA>  NA                 NA                 NA  NA
5       <NA>       <NA>  NA                 NA                 NA  NA
6       <NA>       <NA>  NA                 NA                 NA  NA
  Masih.Dirawat Pulang.dan.Sehat Meninggal ODP.Meninggal
1            NA               NA        NA            NA
2            NA               NA        NA            NA
3            NA               NA        NA            NA
4            NA               NA        NA            NA
5            NA               NA        NA            NA
6            NA               NA        NA            NA
  PDP.Meninggal Isolasi.di.Rumah...21 Selesai.Isolasi...22

1            NA                  <NA>                 <NA>
2            NA                  <NA>                 <NA>
3            NA                  <NA>                 <NA>
4            NA                  <NA>                 <NA>
5            NA                  <NA>                 <NA>
6            NA                  <NA>                 <NA>
  Isolasi.di.Rumah...24 Meninggal...25 Selesai.Isolasi...26
1                  <NA>           <NA>                 <NA>
2                  <NA>           <NA>                 <NA>
3                  <NA>           <NA>                 <NA>
4                  <NA>           <NA>                 <NA>
5                  <NA>           <NA>                 <NA>
6                  <NA>           <NA>                 <NA>
  Meninggal...30 Meninggal...24 Selesai.Isolasi...25 Meninggal...29
1             NA             NA                   NA             NA
2             NA             NA                   NA             NA
3             NA             NA                   NA             NA
4             NA             NA                   NA             NA
5             NA             NA                   NA             NA
6             NA             NA                   NA             NA
  Isolasi.di.Rumah...17 Selesai.Isolasi...18 Isolasi.di.Rumah...20
1                    NA                   NA                    NA
2                    NA                   NA                    NA
3                    NA                   NA                    NA
4                    NA                   NA                    NA
5                    NA                   NA                    NA
6                    NA                   NA                    NA
  Selesai.Isolasi...21 Meninggal...23 Selesai.Isolasi...24
1                   NA             NA                   NA
2                   NA             NA                   NA
3                   NA             NA                   NA
4                   NA             NA                   NA
5                   NA             NA                   NA
6                   NA             NA                   NA
  Meninggal...28 Perawatan.RS Selesai.Isolasi...13
1             NA           NA                   NA
2             NA           NA                   NA
```

```
3             NA           NA                   NA
4             NA           NA                   NA
5             NA           NA                   NA
6             NA           NA                   NA
  Isolasi.di.Rumah...15 Selesai.Isolasi...16 Meninggal...21
1                    NA                   NA             NA
2                    NA                   NA             NA
3                    NA                   NA             NA
4                    NA                   NA             NA
5                    NA                   NA             NA
6                    NA                   NA             NA
```

While combining the different XLSX file into the dataframe, it resulted in duplicated columns. Hence, the next step is to remove these duplicated columns as well as other irrelevant columns.

6.2.2 COALESCE ‘ID_KEL’ & ‘MENINNGAL’ COLUMN

A quick glance at dataframe suggest that there are duplicated ‘ID_KEL’ column. Hence, coalesce needs to be done to ensure that all the ID are present one single ID column.

```
Covid_DF <- Covid_DF %>%
  mutate ( ID_KEL = coalesce ( ID_KEL , ID_KEL...1, ID_KEL...2)
)
```

We will then repeat this step for the ‘Meninngal’ column. Before we coalesce the various Meninggal column, we will have to change the data type of the column as they are of different data type.

```
Covid_DF $ Meninggal...26 = as.double( Covid_DF $ Meninggal...26
)


Covid_DF <- Covid_DF %>%
  mutate ( Meninggal = coalesce ( Meninggal, Meninggal...28,
Meninggal...29, Meninggal...30, Meninggal...31, Meninggal...26) )
```

6.2.3 EXTRACT COLUMN OF INTEREST

While there are many columns in Temp_Covid_DF, the relevant columns for analysis are:

- Name_provinsi (Province)
- name_kota (City)
- nama_kecamatan (District)
- nama_kelurahan (Sub-district)
- Meninggal (Deaths)

- POSITIF (Covid Cases)
- month
- ID

Hence, we will be only be retaining the 8 columns and this is done by selecting the column name.

```
Covid_DF  <-        Covid_DF  %>%       select   (        "Date"   ,"ID_KEL" ,
                                          "Nama_provinsi", "nama_kota",
                                          "nama_kecamatan", "nama_kelurahan",
                                          "POSITIF", "Meninggal")
```

6.2.4 ADDING IN 'DATE' COLUMN

Since the focus of this analysis will require the time period of the cases, we will add a 'Date' column.

A quick look at the XLSX file suggest that a pattern exist:

XLSX File Name: Standar Kelurahan Data Corona (28 Februari 2021 Pukul 10.00).xlsx

The date is formatted as DD-Month-YYY in bracket right before (and the word 'Pukul'. Hence, we will use regular expressions to extract the date.

```
Covid_DF $        Date       <-        str_extract(        Covid_DF $        Date      ,
"(?<=Data Corona \\().*(?= Pukul)")
```

By looking through Temp_Covid_DF, we can see that the month is spelled in Bahasa Indonesia which is the national adminstrative language of Indonesia. With that, we have to set locale to Indonesia and format the date.

```
Sys.setlocale(        locale=        "ind"     )
```

```
[1] "LC_COLLATE=Indonesian_Indonesia.1252;LC_CTYPE=Indonesian_Indonesia.1252;LC_MONETARY=Indonesian_I
```

```
Covid_DF $        Date       <-        c        (        Covid_DF $        Date       )
%>%        as.Date  (        Covid_DF $        Date       , format =        "%d %B %Y"   )
```

6.2.5 TRANSLATING COLUMN NAME OF COVID_DF TO ENGLISH

Next, we will translating column name to English for ease of comprehension

```
Covid_DF  <-        Covid_DF  %>%
  dplyr    ::        rename    (
    Death=        Meninggal, Cases=        POSITIF   , Sub_District=        nama_kelurahan,
    District=        nama_kecamatan, City=        nama_kota, Province=        Nama_provinsi, ID
=        ID_KEL
  )
```

6.2.6 DROPPING COLUMNS

Quick inspection of Covid_DF dataframe suggest that there are non-numeric data in the "ID" column such as:

- BELUM DIKETAHUI
- PROSES UPDATE DATA
- LUAR DKI JAKARTA

Hence, we will proceed to drop these rows.

```
Covid_DF <- Covid_DF [ ! is.na ( Covid_DF $ ID
) ,]

Covid_DF <- Covid_DF [ ! ( Covid_DF $ ID ==
"BELUM DIKETAHUI" | Covid_DF $ ID == "PROSES UPDATE DATA" |
Covid_DF $ ID == "LUAR DKI JAKARTA") ,]
```

6.2.7 CHANGING DATA TYPE OF COLUMN

8. Study Area

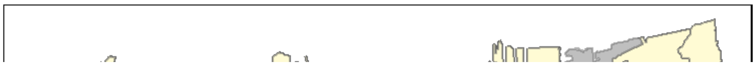
To better understand the study area and Jakarta_Covid dataframe, tmap is used to plot choropleth map to quickly visualize spatial relation of Covid-19 cases and deaths in Jakarta respectively.

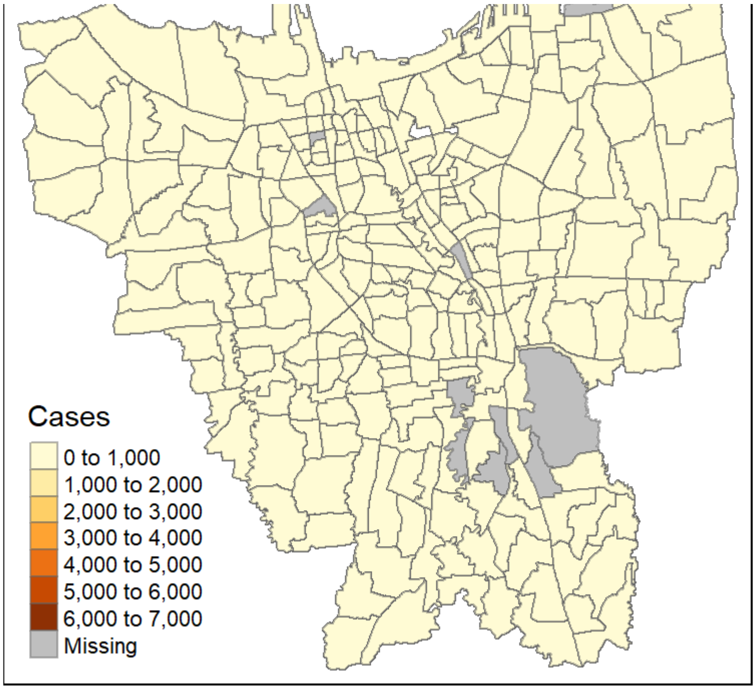
8.1 Joining the Attribute Data & Spatial Data

```
Jakarta_Covid <- left_join( DKI_Jakarta, Covid_DF ,
                           by = c ( "Province" = "Province",
"Sub_District" = "Sub_District",'City' = 'City' ) )
```

8.2 Preliminary Choropleth Map of Covid-19 Cases in Jakarta

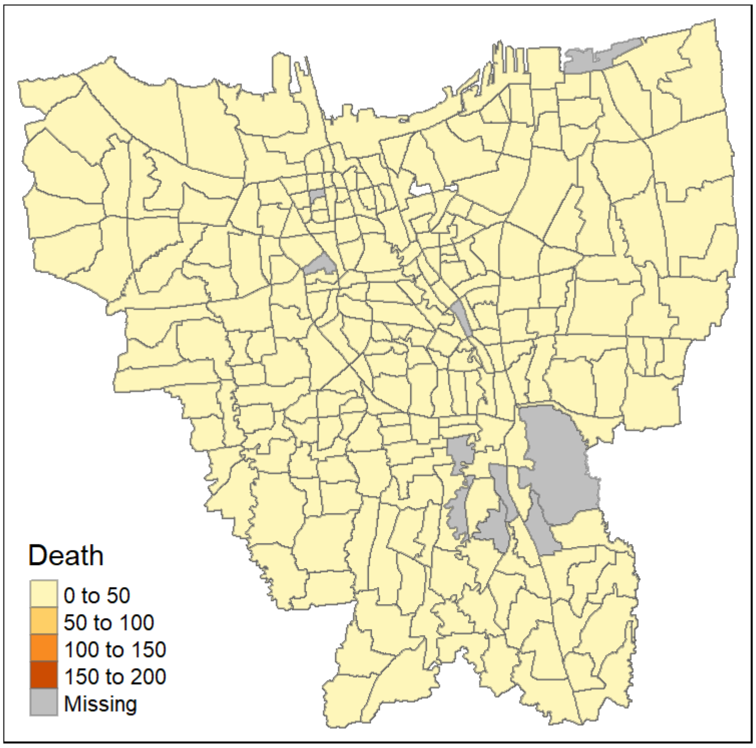
```
tmap_mode( "plot" )
tm_shape ( Jakarta_Covid) +
  tm_fill ( "Cases" ,minimize = TRUE ) +
  tm_borders( alpha = 0.5 )
```





8.3 Preliminnary Choropleth Map of Covid-19 Death in Jakarta

```
tmap_mode(          "plot"    )
tm_shape (          Jakarta_Covid)         +
  tm_fill   (         "Death"   ,minimize =          TRUE      )          +
  tm_borders(         alpha =          0.5       )
```



From the two maps, it is evident that there are missing cases and death data. Hence, in the following segment, we will be investigating the reason behind the missing data and determine if additional data cleaning needs to be done.

9. Data Inspection & Data Cleaning Round 2

```
View(Jakarta_Covid)
View(DKI_Jakarta)
View(Covid_DF )
```

After inspecting the Jakarta_Covid dataframe, it appears that there are spelling error for data in the 'Sub-District' column for DKI_Jakarta and Covid_DF e.g 'KRAMAJATI' vs 'KRAMAT JATI' which resulted in missing data when joining the aspatial & spatial data.

9.1 Identifying Missing Sub-District

To establish a systematic way of checking for missing values, we will compare the two data frame - DKI_Jakarta and Covid_DF. The following code chunk will identify the missing 'sub-district' values.

```
Covid_SD <- c(Covid_DF$Sub_District)
Jakarata_SD <- c(DKI_Jakarta$Sub_District)


Covid_SD[!(Covid_SD %in% Jakarata_SD)]
```

```
 [1] "BALE KAMBANG"           "HALIM PERDANA KUSUMAH"
 [3] "JATI PULO"              "KALI BARU"
 [5] "KAMPUNG TENGAH"         "KERENDANG"
 [7] "KRAMAT JATI"            "PAL MERIAM"
 [9] "PINANG RANTI"           "PULAU HARAPAN"
[11] "PULAU KELAPA"           "PULAU PANGGANG"
[13] "PULAU PARI"             "PULAU TIDUNG"
[15] "PULAU UNTUNG JAWA"      "RAWA JATI"
[17] "HALIM PERDANA KUSUMAH" "JATI PULO"
[19] "KRAMAT JATI"            "PINANG RANTI"
[21] "BALE KAMBANG"           "KALI BARU"
[23] "RAWA JATI"              "KAMPUNG TENGAH"
[25] "KERENDANG"              "PAL MERIAM"
[27] "PULAU HARAPAN"          "PULAU KELAPA"
[29] "PULAU PANGGANG"         "PULAU PARI"
[31] "PULAU TIDUNG"           "PULAU UNTUNG JAWA"
[33] "BALE KAMBANG"           "HALIM PERDANA KUSUMAH"
[35] "JATI PULO"              "KALI BARU"
[37] "KAMPUNG TENGAH"         "KERENDANG"
[39] "KRAMAT JATI"            "PAL MERIAM"
[41] "PINANG RANTI"           "PULAU HARAPAN"
[43] "PULAU KELAPA"           "PULAU PANGGANG"
[45] "PULAU PARI"             "PULAU TIDUNG"
[47] "PULAU UNTUNG JAWA"      "RAWA JATI"
```

```
 [49] "HALIM PERDANA KUSUMAH" "JATI PULO"
 [51] "KRAMAT JATI"          "PINANG RANTI"
 [53] "BALE KAMBANG"         "KALI BARU"
 [55] "RAWA JATI"            "KAMPUNG TENGAH"
 [57] "KERENDANG"            "PAL MERIAM"
 [59] "PULAU HARAPAN"        "PULAU KELAPA"
 [61] "PULAU PANGGANG"       "PULAU PARI"
 [63] "PULAU TIDUNG"         "PULAU UNTUNG JAWA"
 [65] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
 [67] "JATI PULO"            "KALI BARU"
 [69] "KAMPUNG TENGAH"       "KERENDANG"
 [71] "KRAMAT JATI"          "PAL MERIAM"
 [73] "PINANG RANTI"         "PULAU HARAPAN"
 [75] "PULAU KELAPA"         "PULAU PANGGANG"
 [77] "PULAU PARI"           "PULAU TIDUNG"
 [79] "PULAU UNTUNG JAWA"    "RAWA JATI"
 [81] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
 [83] "JATI PULO"            "KALI BARU"
 [85] "KAMPUNG TENGAH"       "KERENDANG"
 [87] "KRAMAT JATI"          "PAL MERIAM"
 [89] "PINANG RANTI"         "PULAU HARAPAN"
 [91] "PULAU KELAPA"         "PULAU PANGGANG"
 [93] "PULAU PARI"           "PULAU TIDUNG"
 [95] "PULAU UNTUNG JAWA"    "RAWA JATI"
 [97] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
 [99] "JATI PULO"            "KALI BARU"
[101] "KAMPUNG TENGAH"       "KERENDANG"
[103] "KRAMAT JATI"          "PAL MERIAM"
[105] "PINANG RANTI"         "PULAU HARAPAN"
[107] "PULAU KELAPA"         "PULAU PANGGANG"
[109] "PULAU PARI"           "PULAU TIDUNG"
[111] "PULAU UNTUNG JAWA"    "RAWA JATI"
[113] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
[115] "JATI PULO"            "KALI BARU"
[117] "KAMPUNG TENGAH"       "KERENDANG"
[119] "KRAMAT JATI"          "PAL MERIAM"
[121] "PINANG RANTI"         "PULAU HARAPAN"
[123] "PULAU KELAPA"         "PULAU PANGGANG"
[125] "PULAU PARI"           "PULAU TIDUNG"
[127] "PULAU UNTUNG JAWA"    "RAWA JATI"
[129] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
[131] "JATI PULO"            "KALI BARU"
[133] "KAMPUNG TENGAH"       "KERENDANG"
[135] "KRAMAT JATI"          "PAL MERIAM"
[137] "PINANG RANTI"         "PULAU HARAPAN"
[139] "PULAU KELAPA"         "PULAU PANGGANG"
[141] "PULAU PARI"           "PULAU TIDUNG"
[143] "PULAU UNTUNG JAWA"    "RAWA JATI"
[145] "BALE KAMBANG"         "HALIM PERDANA KUSUMAH"
[147] "JATI PULO"            "KALI BARU"
[149] "KAMPUNG TENGAH"       "KERENDANG"
```

```
[151] "KRAMAT JATI"           "PAL MERIAM"
[153] "PINANG RANTI"          "PULAU HARAPAN"
[155] "PULAU KELAPA"          "PULAU PANGGANG"
[157] "PULAU PARI"            "PULAU TIDUNG"
[159] "PULAU UNTUNG JAWA"     "RAWA JATI"
[161] "BALE KAMBANG"          "HALIM PERDANA KUSUMAH"
[163] "JATI PULO"             "KALI BARU"
[165] "KAMPUNG TENGAH"        "KERENDANG"
[167] "KRAMAT JATI"           "PAL MERIAM"
[169] "PINANG RANTI"          "PULAU HARAPAN"

[171] "PULAU KELAPA"          "PULAU PANGGANG"
[173] "PULAU PARI"            "PULAU TIDUNG"
[175] "PULAU UNTUNG JAWA"     "RAWA JATI"
[177] "PINANG RANTI"          "BALE KAMBANG"
[179] "PAL MERIAM"            "JATI PULO"
[181] "KALI BARU"             "RAWA JATI"
[183] "KERENDANG"             "KAMPUNG TENGAH"
[185] "KRAMAT JATI"           "HALIM PERDANA KUSUMAH"
[187] "P. HARAPAN"            "P. KELAPA"
[189] "P. PANGGANG"           "P. PARI"
[191] "P. TIDUNG"             "UNTUNG JAWA"
[193] "BALE KAMBANG"          "HALIM PERDANA KUSUMAH"
[195] "JATI PULO"             "KALI BARU"
[197] "KAMPUNG TENGAH"        "KERENDANG"
[199] "KRAMAT JATI"           "PAL MERIAM"
[201] "PINANG RANTI"          "PULAU HARAPAN"
[203] "PULAU KELAPA"          "PULAU PANGGANG"
[205] "PULAU PARI"            "PULAU TIDUNG"
[207] "PULAU UNTUNG JAWA"     "RAWA JATI"
[209] "HALIM PERDANA KUSUMAH" "JATI PULO"
[211] "KRAMAT JATI"           "PINANG RANTI"
[213] "BALE KAMBANG"          "KALI BARU"
[215] "RAWA JATI"             "KAMPUNG TENGAH"
[217] "KERENDANG"             "PAL MERIAM"
[219] "PULAU HARAPAN"         "PULAU KELAPA"
[221] "PULAU PANGGANG"        "PULAU PARI"
[223] "PULAU TIDUNG"          "PULAU UNTUNG JAWA"
[225] "BALE KAMBANG"          "HALIM PERDANA KUSUMAH"
[227] "JATI PULO"             "KALI BARU"
[229] "KAMPUNG TENGAH"        "KERENDANG"
[231] "KRAMAT JATI"           "PAL MERIAM"
[233] "PINANG RANTI"          "PULAU HARAPAN"
[235] "PULAU KELAPA"          "PULAU PANGGANG"
[237] "PULAU PARI"            "PULAU TIDUNG"
[239] "PULAU UNTUNG JAWA"     "RAWA JATI"
[241] "BALE KAMBANG"          "HALIM PERDANA KUSUMAH"
[243] "JATI PULO"             "KALI BARU"
[245] "KAMPUNG TENGAH"        "KERENDANG"
[247] "KRAMAT JATI"           "PAL MERIAM"
[249] "PINANG RANTI"          "PULAU HARAPAN"
[251] "PULAU KELAPA"          "PULAU PANGGANG"
```

```
[253] "PULAU PARI"            "PULAU TIDUNG"
[255] "PULAU UNTUNG JAWA"     "RAWA JATI"
```

From the output, it is evident that the following sub-districts are spelled incorrectly:

- KRAMATJATI (Correct: 'KRAMAT JATI')
- PAL MERAH (Correct 'PALMERAH')
- PALMERIAM (Correct: 'PAL MERIAM')
- KALIBARU (Correct: 'KALI BARU')
- RAWAJATI (Correct: 'RAWA JATI')
- JATIPULO (Correct: 'JATI PULO')
- KRENDANG (Correct: 'KERENDANG')
- PINANGRANTI (Correct: 'PINANG RANTI')
- BALEKAMBANG (Correct: 'BALE KAMBANG')
- HALIM PERDANA KUSUMA (Correct: HALIM PERDANA KUSAMAH)
- KALI DERES (Correct: KALIDERES)

Apart from spelling mistakes,there were also sub-districts value that have have missing word

- TENGAH (Correct: 'KAMPUNG TENGAH')

9.2 Clean Sub-District Data

The following code chunk corrects the misspelt sub-district in preparation for joining the attribute data & spatial data in the next step.

```
DKI_Jakarta <-         DKI_Jakarta %>%       mutate    (        Sub_District =          ifelse
(         as.character(         Sub_District)          ==        "KRAMATJATI", "KRAMAT JATI"    ,
as.character(         Sub_District)         )         )
DKI_Jakarta <-         DKI_Jakarta %>%       mutate    (        District =          ifelse
(         as.character(         District )          ==        "PAL MERAH"     , "PALMERAH",
as.character(         District )         )         )
DKI_Jakarta <-         DKI_Jakarta %>%       mutate    (        Sub_District =          ifelse
(         as.character(         Sub_District)          ==        "PALMERIAM", "PAL MERIAM"     ,
as.character(         Sub_District)         )         )
DKI_Jakarta <-         DKI_Jakarta %>%       mutate    (        Sub_District =          ifelse
(         as.character(         Sub_District)          ==        "KALIBARU", "KALI BARU"    ,
as.character(         Sub_District)         )         )
DKI_Jakarta <-         DKI_Jakarta %>%       mutate    (        Sub_District =          ifelse
(         as.character(         Sub_District)          ==        "RAWAJATI", "RAWA JATI"    ,
as.character(         Sub_District)         )         )
```

```
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "TENGAH" , "KAMPUNG TENGAH" ,
as.character( Sub_District) ) )
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "JATIPULO", "JATI PULO" ,
as.character( Sub_District) ) )
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "KRENDANG", "KERENDANG",
as.character( Sub_District) ) )
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "PINANGRANTI", "PINANG RANTI" ,
as.character( Sub_District) ) )
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "BALEKAMBANG", "BALE KAMBANG" ,
as.character( Sub_District) ) )
DKI_Jakarta <- DKI_Jakarta %>% mutate ( Sub_District = ifelse
( as.character( Sub_District) == "HALIM PERDANA KUSUMA",
"HALIM PERDANA KUSUMAH", as.character( Sub_District) ) )
Covid_DF <- Covid_DF %>% mutate ( District = ifelse (
as.character( District ) == "KALI DERES" , "KALIDERES", as.character
( District ) ) )
```

9.3 Joining the Attribute Data & Spatial Data

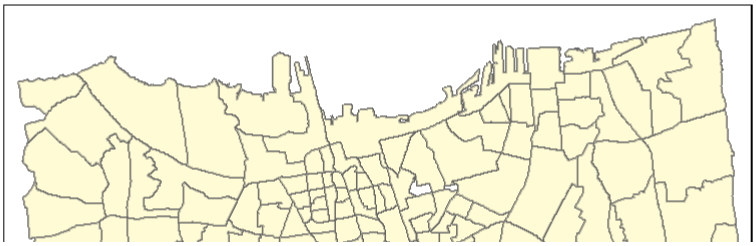
To check the sub_district data, we will have to left join the DKI_Jakarta dataframe and Covid_DF dataframe again.

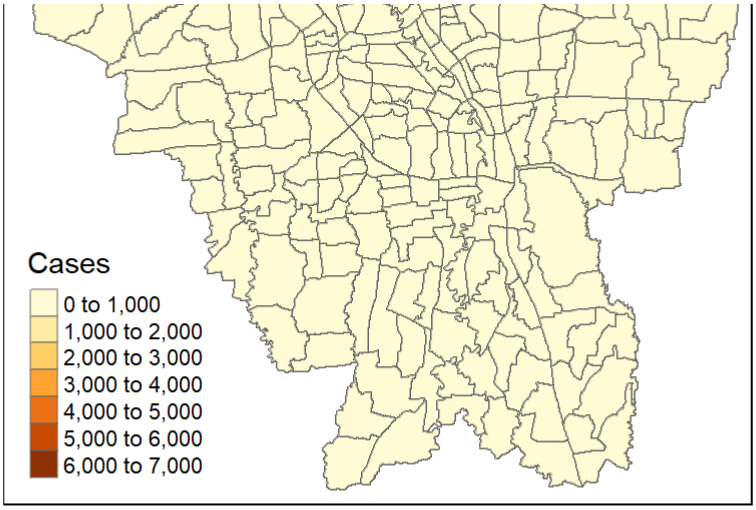
```
Jakarta_Covid <- left_join( DKI_Jakarta, Covid_DF ,
                             by = c ( "Sub_District" = "Sub_District"
) )
```

9.4 Checking Sub-District Data

Plotting the cases against the map of Jakarta to verify that all the misspelled sub-district and district are corrected.

```
tmap_mode( "plot" )
tm_shape ( Jakarta_Covid) +
  tm_fill ( "Cases" ) +
  tm_borders( alpha = 0.5 )
```





- From the output, we can see that all the data are now corrected.

10. Writing and Reading RDS

10.1 Writing RDS

Next, we will use the write_rds() function to export the data frame.

10.2 Read RDS

11. EXPLORATORY DATA ANALYSIS

```
Case_Rate <-         Covid_DF  %>%
  inner_join(         DKI_Jakarta, by=        c         (         "Sub_District" =
"Sub_District")         )          %>%
  group_by (          Sub_District, Date      )          %>%
  dplyr    ::         summarise(         `Cuml_Case_Rate` =          (          (          sum
(         Cases     )          /          (         Total_Population )          )          *
10000     )          )          %>%
  ungroup  (          )          %>%       pivot_wider(        names_from =          Date      ,
            values_from =          Cuml_Case_Rate)


summary  (         Case_Rate)
```

```
Sub_District          2020-03-31        2020-04-30
Length:261          Min.   : 0.0000   Min.   : 0.000
Class :character    1st Qu.: 0.0000   1st Qu.: 1.393
Mode  :character    Median : 0.3264   Median : 2.220
                    Mean   : 0.7609   Mean   : 3.370
                    3rd Qu.: 0.6928   3rd Qu.: 4.016
```

```
                   Max.   :49.8826   Max.   :49.883
  2020-05-31       2020-06-30        2020-07-31
 Min.   : 0.000   Min.   :  0.000   Min.   :  1.518
 1st Qu.: 2.646   1st Qu.:  4.179   1st Qu.:  7.477
 Median : 4.198   Median :  6.515   Median : 10.690
 Mean   : 5.458   Mean   :  8.728   Mean   : 14.002
 3rd Qu.: 6.796   3rd Qu.: 10.631   3rd Qu.: 15.758
 Max.   :49.883   Max.   :105.336   Max.   :112.243
  2020-08-31        2020-09-30        2020-10-31
 Min.   :  2.429   Min.   :  6.681   Min.   : 13.82
 1st Qu.: 14.134   1st Qu.: 32.867   1st Qu.: 54.17
 Median : 19.532   Median : 41.312   Median : 64.34
 Mean   : 25.203   Mean   : 51.530   Mean   : 76.97
 3rd Qu.: 31.381   3rd Qu.: 58.183   3rd Qu.: 85.28
 Max.   :210.492   Max.   :511.658   Max.   :605.57
  2020-11-30       2020-12-31        2021-02-28
 Min.   : 28.85   Min.   :  42.06   Min.   :  75.2
 1st Qu.: 75.33   1st Qu.: 106.54   1st Qu.: 217.0
 Median : 88.97   Median : 124.56   Median : 256.6
 Mean   :103.09   Mean   : 142.66   Mean   : 280.1
 3rd Qu.:110.95   3rd Qu.: 152.73   3rd Qu.: 309.5
 Max.   :783.68   Max.   :1036.27   Max.   :1632.1
  2021-03-31        2021-04-30        2021-05-31
 Min.   :  83.71   Min.   :  90.04   Min.   :  91.88
 1st Qu.: 247.10   1st Qu.: 264.21   1st Qu.: 276.21
 Median : 294.83   Median : 315.17   Median : 333.16
 Mean   : 318.40   Mean   : 342.78   Mean   : 362.22
 3rd Qu.: 348.82   3rd Qu.: 372.94   3rd Qu.: 391.92

 Max.   :1839.38   Max.   :2014.25   Max.   :2075.78
  2021-06-30       2021-07-31
 Min.   : 119.4   Min.   : 187.3
 1st Qu.: 360.0   1st Qu.: 545.1
 Median : 423.9   Median : 658.3
 Mean   : 465.3   Mean   : 705.3
 3rd Qu.: 503.4   3rd Qu.: 779.7
 Max.   :2726.7   Max.   :3808.3
```

- Based on summary statistics, there is generally an increase in the number of COVID-19 cases in Jakarta with time between March 2020 and July 2021 , as observed from the increasing mean COVID-19 case rates across the months.

12. Thematic Mapping

To better understand the spatio-temporal distribution of COVID-19 at the sub_district level, choropleth mapping techniques will be utilised for the analysis.

Choropleth maps visualising the spatial distribution of COVID-19 rates across sub_district in Jakarta, will be plotted across time (March 2020 to July 2021). Covid Cases Per 10k Population will be visualised instead of the number of COVID-19 cases to standardised population sizes for a more holistic comparison.

12.1 CUMULATIVE CONFIRMED CASES

12.1.1 DATA PREPARATION

The following code chunk will inner join join the attribute data (Covid_DF) & spatial data (DKI_Jakarta).

Following which, the cumulative confirmed cases per 10,0000 population will be calculated using the following formula:

$$Monthly\ Cumulative\ Confirmed\ Cases\ = \frac{Total\ no\ of\ Covid-19\ cases\ at\ Sub-District\ Lev}{Total\ Population\ of\ the\ Sub-District}$$

After which, we will then covert Jakarta_Covid_Cases into sf.

```
Jakarta_Covid_Cases <-        Covid_DF   %>%
  inner_join(        DKI_Jakarta, by=        c         (         "Sub_District"=
"Sub_District")         )          %>%
  group_by (         Sub_District, Date      )         %>%
  dplyr    ::        summarise(        `Cases Per 10k Population` =         (         (
sum       (         Cases     )          /          (         Total_Population )         )
*         10000     )         )          %>%       ungroup  (         )

Jakarta_Covid_Cases <-        Jakarta_Covid_Cases%>%       left_join(        DKI_Jakarta,
                        by=        c         (         "Sub_District"=        "Sub_District")
)

Jakarta_Covid_Cases<-        st_as_sf (        Jakarta_Covid_Cases)
```

12.1.2 PLOTTING CHOROPLETH MAP OF MONTHLY CUMULATIVE CONFIRMED CASES

In the code chunk below, tm_shape() is used to define the input data (Jakarta_Covid_Cases) and tm_fill() is used to illustrate the monthly cumulative confirmed cases at sub-district level.

Classification Method

Custom breaks will have to be specified explicitly to construct the classification scheme for Covid Cases Per 10k Population.

To guide the specification of breakpoints, descriptive statistics of Covid Cases Per 10k Population across months are first computed and studied.

```
summary  (         Jakarta_Covid_Cases[         "Cases Per 10k Population"]          )
```

```
 Cases Per 10k Population          geometry
 Min.    :   0.000         MULTIPOLYGON :4176
 1st Qu.:   9.169         epsg:23845   :    0
```

```
Median :  81.846        +proj=tmer...:   0
Mean   : 181.618
3rd Qu.: 295.391
Max.   :3808.290
```

- It can be observed that Covid Cases Per 10k Population rate range from 0 to 3808 across sub district, from March 2020 to July 2021.

Break Point

To choose an appropriate number of classes, we will use the sturges formula

$$No\ of\ Classes = 1 + 1.32 * Log(Number\ of\ Values)$$

```
Classes = 1 + 1.32 * log ( 4176 )
Classes
```

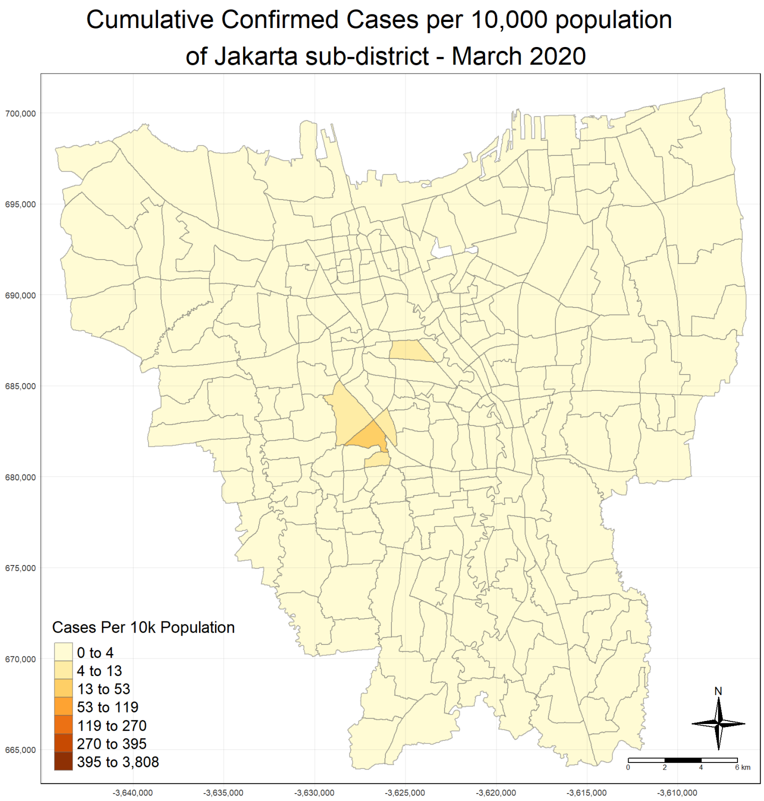
```
[1] 12.00498
```

With the result and considering legibility, we will set the number of classes to be 7

```
Classes = 1 + 1.32 * log ( 4176 )
Classes
```

```
[1] 12.00498
```

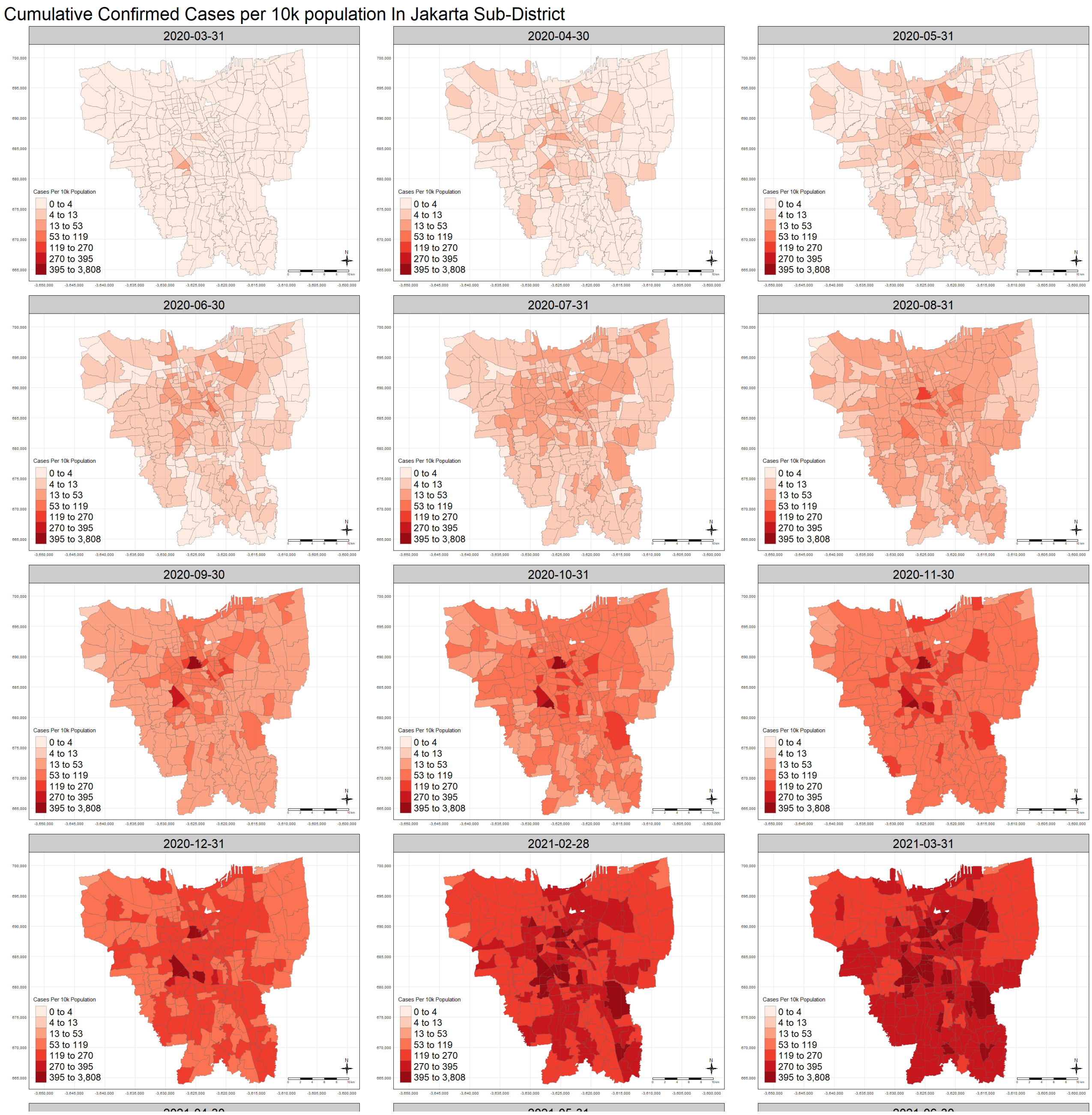
The choropleth map is plotted with custom classification scheme.

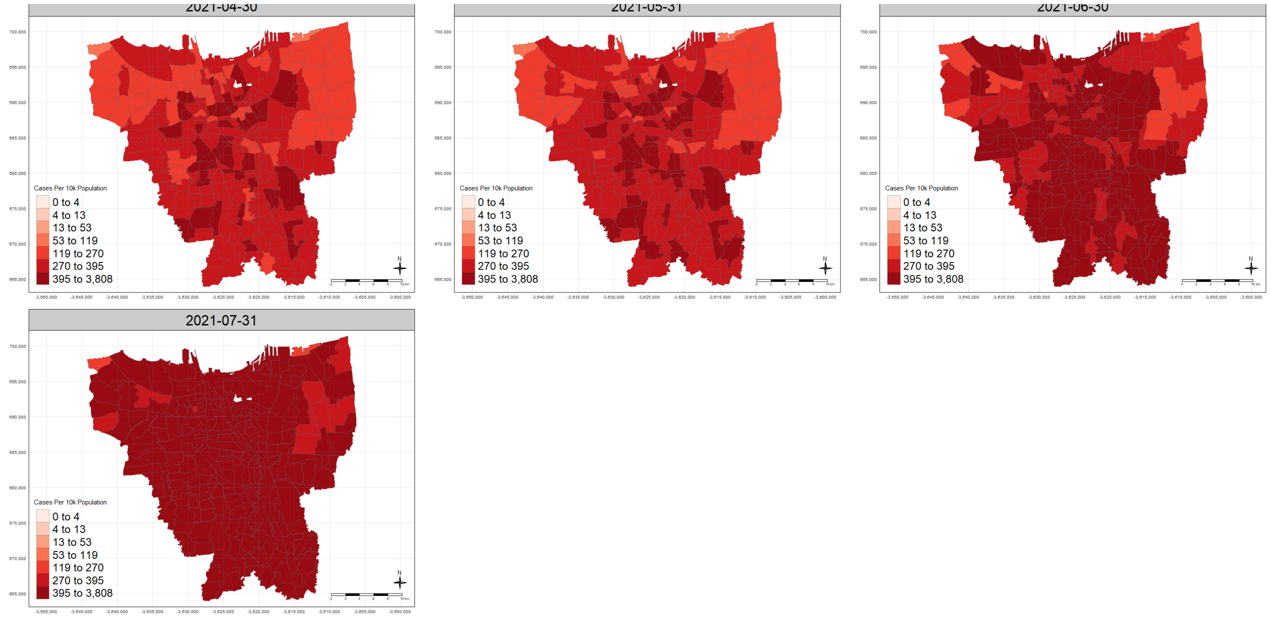


- From the choropleth map, it can observe that in March 2020, the sub-district with the highest case per 10k population is around south-west Jakarta, specifically Senayan.
- A darker shade of oranange indicates a higher COVID-19 rate per 10k population.
- It is also interesting to note that sub_district near Senayan such as Gelora and Karet Semmangi, Rawa Barat appears to have higher COVID-19 rate per 10k population compared to other sub-district.

12.1.3 TIME-SERIES CHOROPLETH MAP OF COVID-19 RATES

By using tm group by date in TM_FACETS, we can see the spatial-temporal patterns of COVID-19 case in DKI Jakarta between March 2020 to July 2021.





- It can be observed that COVID-19 cases seem to spread outwards to the neighbouring sub-district with time.
- In the first 3 month (Mar 2020 - May 2020), it appears that COVID-19 cases are mostly concentrated around the central and western Jakarta.
- By August 2020, sub-district with the highest COVID-19 cases per 10k population (darker red areas) are mostly found in central jakarta
- In the first half of 2021, COVID-19 cases per 10k population appears to spread throughout Jakarta. However, it is to noted that due to the large class interval of 395 to 3808, difference between the various sub_district may not be apparently from April 2021 onwards.

12.1.4 ANIMATED TIME-SERIES CHOROPLETH MAP OF COVID-19 RATES

To better visualize the changes across the various sub-district through time, we will plot an animated map with the same data.

Time-series choropleth map of COVID-19 Rates

Figure 1: Time-series choropleth map of COVID-19 Rates

```
knitr    ::      include_graphics(
"C:/Users/User/Desktop/IS415/lye-jia-wei/IS415_blog/_site/posts/2021-08-30-take-home-exercise-
        1/Covd_Cases_Animation.gif"
)
```

12.2 CUMULATIVE COVID-19 DEATH

12.2.1 Data Preparation

The following code chunk will omit rows with missing month values and join the attribute data (Covid_DF) & spatial data (DKI_Jakarta).

Following which, the cumulative death per 10,0000 population will be calculated using the following formula:

$$Monthly\ Cumulative\ Confirmed\ Death = \frac{Total\ no\ of\ Covid-19\ Death\ at\ Sub-District\ Le}{Total\ Population\ of\ the\ Sub-District}$$

After which, we will then covert Jakarta_Covid_Cases into sf.

```
Jakarta_Death <- Covid_DF %>%
  inner_join( DKI_Jakarta, by= c ( "Sub_District"=
"Sub_District") ) %>%
  group_by ( Sub_District, Date ) %>%
  dplyr :: summarise( `Death Per 10k Population` = ( (
sum ( Death ) / ( Total_Population) )
) * 10000 ) %>% ungroup ( )

Jakarta_Death <- Jakarta_Death %>% left_join( DKI_Jakarta,
                     by= c ( "Sub_District"= "Sub_District")
)

Jakarta_Death <- st_as_sf ( Jakarta_Death )
```

10.2.2 PLOTTING CHOROPLETH MAP OF MONTHLY CUMULATIVE DEATH

In the code chunk below, tm_shape() is used to define the input data (Jakarta_Death) and tm_fill() is used to illustrate the monthly cumulative confirmed cases at sub-district level.

Classification Method

Custom breaks will have to be specified explicitly to construct the classification scheme for Covid Death Per 10k Population.

To guide the specification of breakpoints, descriptive statistics of Covid Death Per 10k Population across months are first computed and studied.

```
summary ( Jakarta_Death[ "Death Per 10k Population"] )
```

```
 Death Per 10k Population          geometry
 Min.   : 0.0000          MULTIPOLYGON :4176
```

```
 1st Qu.: 0.4592          epsg:23845    :   0  
 Median : 1.8004          +proj=tmer...:   0  
 Mean   : 3.1676                              
 3rd Qu.: 5.1803                              
 Max.   :42.0984                              
```

- It can be observed that Covid Death Per 10k population rate range from 0 to 42across sub district, from March 2020 to July 2021.

Break Point

To choose an appropriate number of classes, we will use the sturges formula

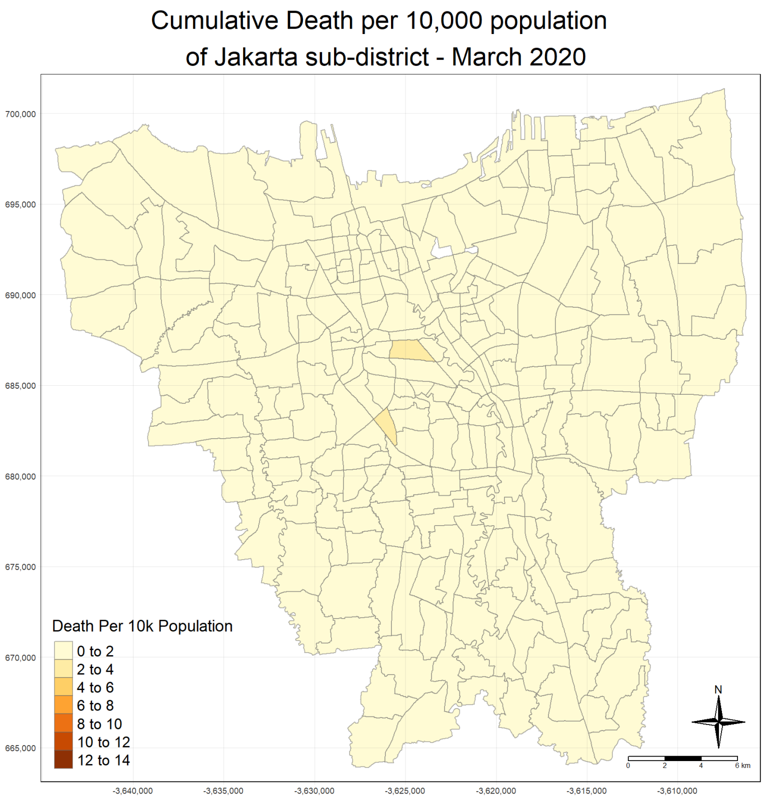
$$No\ of\ Classes = 1 + 1.32 * Log(Number\ of\ Values)$$

```
Classes = 1 + 1.32 * log ( 4176 )
Classes
```

```
[1] 12.00498
```

With the result and considering legibility, we will set the number of classes to be 7

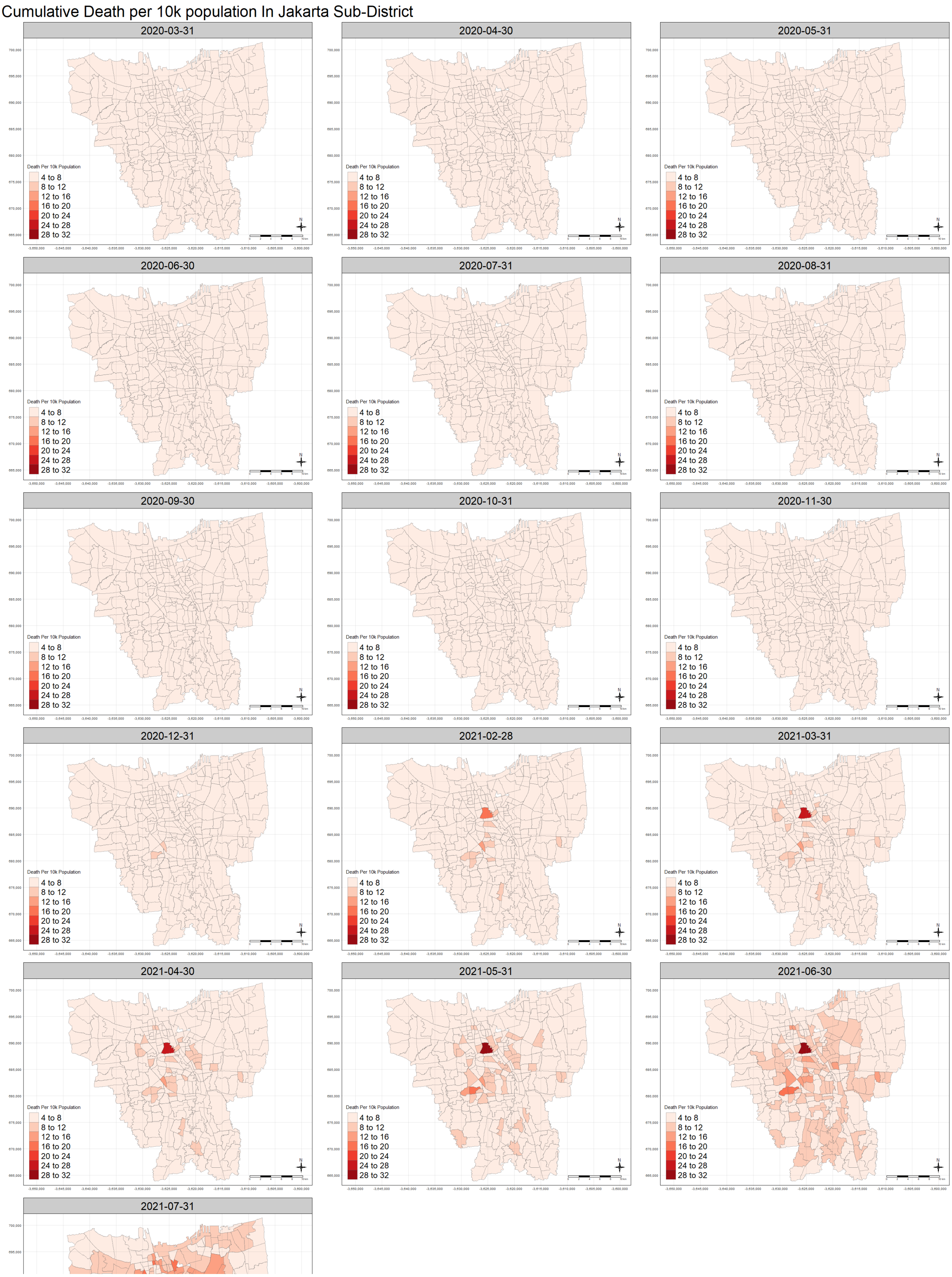
The choropleth map is plotted with custom classification scheme.

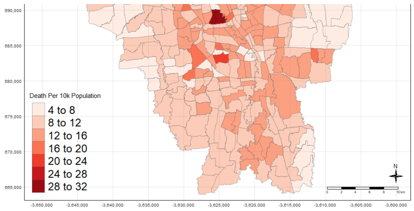


- From the map, it can be seen that Gondangdia and Senayan are the 2 sub-district with the highest Covid death in March 2020.

12.2.3 TIME-SERIES CHOROPLETH MAP OF COVID-19 RATES

By using tm group by date in TM_FACETS, we can see the spatial-temporal patterns of COVID-19 death in DKI Jakarta between March 2020 to July 2021.





- From the map, it is evident that despite the high covid case per 10k population shown earlier starkly contrast with the map depicitng covid death per 10k population. This may suggest that Covid-19 death rate is relatively low in the earlier period e.g March 2020 to Dec 2020
- By Feb 2021, one particular sub-district, Gambir stood out as it is the only sub-district with a high (24-28) death per 10k population
- Death per 10k population increases sharply after May 2020 and appears to be higher in Central Jakarta. The sharp rise in death per 10k population may be a result of the more fatal Covid-19 Delta variant, though additional statistical testing needs to be conducted to prove this hypothesis.

12.1.4 ANIMATED TIME-SERIES CHOROPLETH MAP OF COVID-19 RATES

To better visualize the changes in death rate across the various sub-district through time, we will plot an animated map with the same data.

Time-series choropleth map of COVID-19 Rates

Figure 2: Time-series choropleth map of COVID-19 Rates

13. Analytical Map

13.1 BARCHART

To better understand Jakarta sub-district which has been affected by Covid-19 the most in terms of infection rate and death rate, we will now proceed to plot bar chart that shows the top 10 district with highest Covid-19 cases and death from March 2020 to July 2021.

13.1.1 Bar Chart of Top 10 Sub-District With Highest Covid-19 Cases Per 10,000 Population

13.1.1.1 Combining aspatial and spatial dataframe

Again, we will combine the Covid_DF and DKI_Jakarta data frame by sub_district. We will use the same formula to calculate the Covid cases per 10,000 population and it will be named as 'Covid_Case_10K'.

```
Jakarta_Covid_Sub_District <-        Covid_DF   %>%
  left_join(        DKI_Jakarta, by=        c        (        "Sub_District"=
"Sub_District")        )        %>%
  group_by (        Sub_District)        %>%
  dplyr    ::        summarise(        `Covid_Case_10k` =        (        (        sum
(        Cases     )        /        (        Total_Population )        )        *
10000     )        )        %>%        ungroup  (        )
```

13.1.1.2 Dropping duplicated and NA Rows

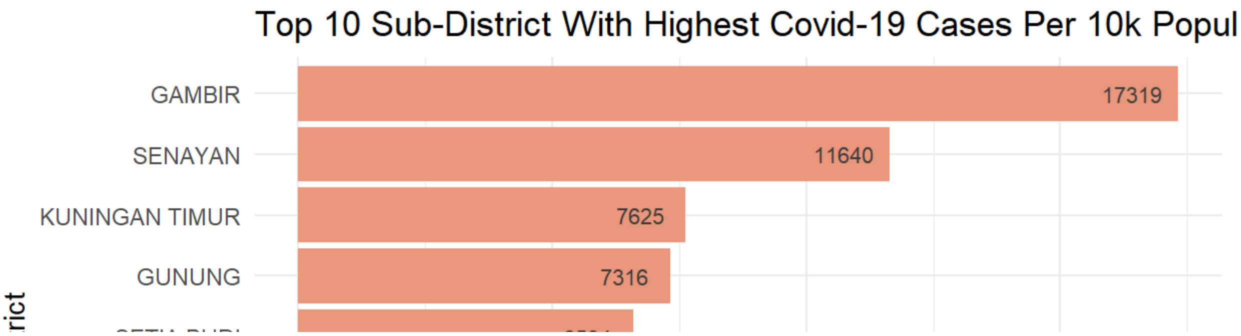
Next, we will get drop the duplicated row as well as the NA rows.

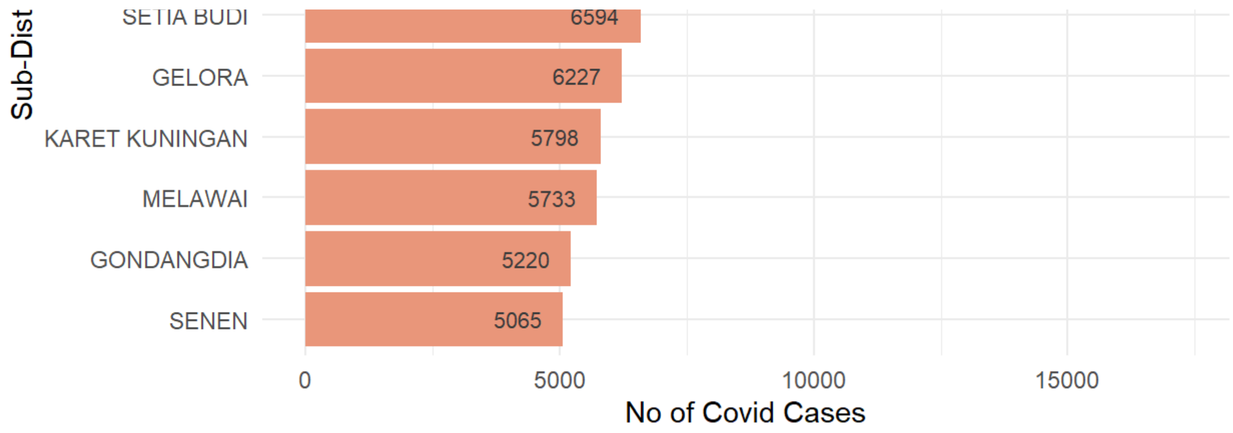
```
Jakarta_Covid_Sub_District <-        Jakarta_Covid_Sub_District[        !        duplicated
(        Jakarta_Covid_Sub_District)        , ]

Jakarta_Covid_Sub_District$        Covid_Case_10k <-        round    (
Jakarta_Covid_Sub_District$        Covid_Case_10k ,0        )
```

13.1.1.3 Plotting barchart

Following which, we will sort the sub_district by covid cases per 10k population and only plot the top 10 sub_district with highest covid cases.

```
top_n    (        Jakarta_Covid_Sub_District, n=        10        , Covid_Case_10k)
%>%
          ggplot   (        .        , aes      (        x=        Covid_Case_10k, y=
reorder  (        Sub_District, Covid_Case_10k)        ,label=        (        Covid_Case_10k
)        )        )        +
              geom_bar (        stat=        'identity')        +
  geom_col (        fill=        'darksalmon')        +
  labs     (        title=
'Top 10 Sub-District With Highest Covid-19 Cases Per 10k Population',
       x=        'No of Covid Cases',
       y=        'Sub-District'    )        +
  geom_text(        nudge_x=        -        900.85    ,vjust =        0.5       , colour=
'gray23' , size=        2.87      )        +
  theme_minimal(        )
```





- From the barchart, we can see that Gambir is the sub district with the highest Covid-19 cases per 10k population in Jakarta between March 2020 and July 2021.
- To note that the top 3 sub-districted highlighted in the barchart are located close to each other as seen from the Choropleth map

13.1.2 Bar Chart of Top 10 Sub-District With Highest Covid-19 Death Per

10,000 Population

13.1.2.1 Combining aspatial and spatial dataframe

Again, we will combine the Covid_DF and DKI_Jakarta data frame by sub_district. We will use the same formula to calculate the Covid death per 10,000 population and it will be named as 'Death_Per_10K'.

```
Jakarta_Death_Sub_District <-         Covid_DF   %>%
  left_join(         DKI_Jakarta, by=         c          (          "Sub_District"=
"Sub_District")          )          %>%
  group_by (          Sub_District)          %>%
  dplyr    ::        summarise(         Death_Per_10k =          (          (          sum
(          Death      )          /          (          Total_Population )          )          *
10000      )          )          %>%        ungroup  (          )
```

12.1.1.2 Dropping duplicated and NA Rows

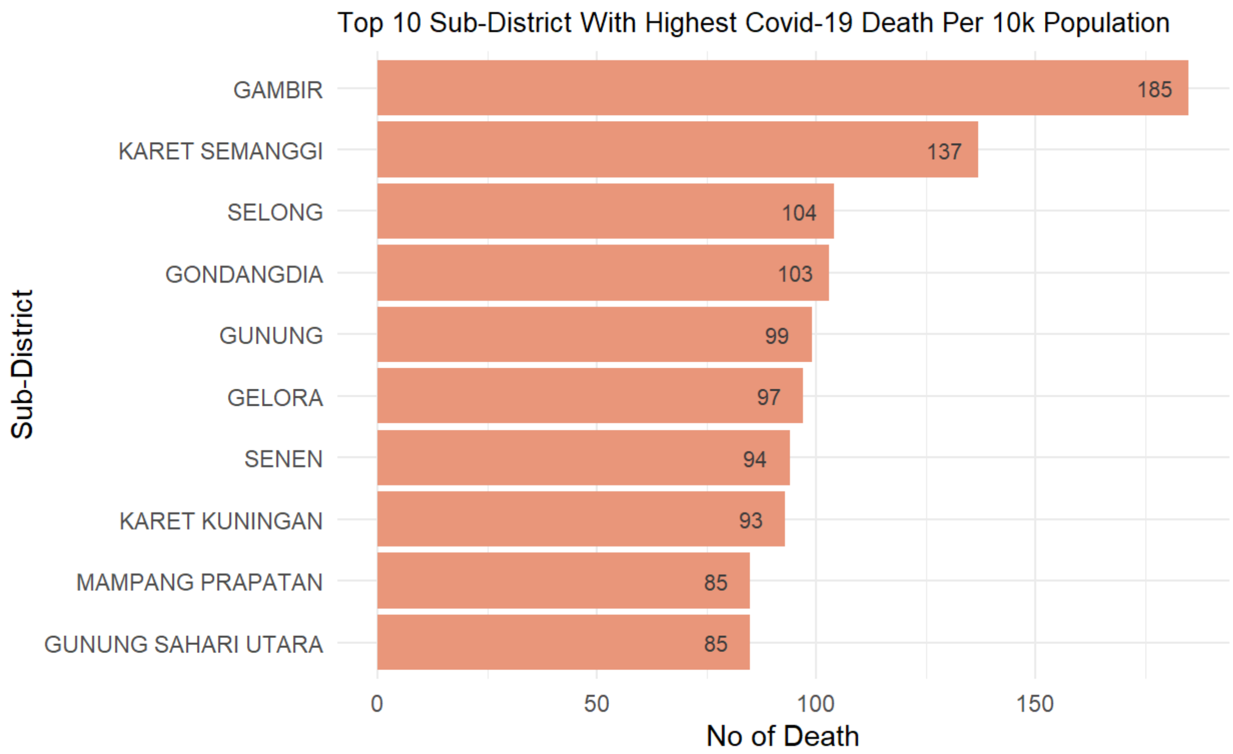
Next, we will get drop the duplicated row as well as the NA rows.

```
Jakarta_Death_Sub_District <-        Jakarta_Death_Sub_District[         !         duplicated
(         Jakarta_Death_Sub_District)         , ]

Jakarta_Death_Sub_District$        Death_Per_10k <-        round     (
Jakarta_Death_Sub_District$        Death_Per_10k ,0         )
```

12.1.1.3 Bar Chart

Following which, we will sort the sub_district by covid death per 10k population and only plot the top 10 sub_district with highest covid death.

```
top_n     (         Jakarta_Death_Sub_District, n=        10        , Death_Per_10k)
%>%
          ggplot   (         .         , aes       (         x=         Death_Per_10k, y=
reorder  (         Sub_District, Death_Per_10k)         ,label=         (         Death_Per_10k
)         )         )         +
              geom_bar (         stat=         'identity')         +
  geom_col (         fill=         'darksalmon')         +
  labs     (         title=
'Top 10 Sub-District With Highest Covid-19 Death Per 10k Population',
       x=         'No of Death'  ,
       y=         'Sub-District'    )         +
  geom_text(         nudge_x=         -         7.85     ,vjust =         0.5      , colour=
'gray23' , size=        2.87      )         +
  theme_minimal(         )         +         theme    (         plot.title =         element_text
(         size=        10        )         )
```



- As pointed out previously in the Choropleth map, Gambir has one of the highest Covid-19 death per 10k population
- Again, we can observe that the top sub-district with highest Covid-19 death per 10k population appears to be geographically near to one another
- To note, the top 10 district with highest Covid-19 cases and Covid-19 death per 10k population differs slightly

slightly.

#12.2 Box Map

A box map will be used to visualise covid cases spatially across different sub_district in Jakarta.

A customised classification scheme for the choropleth map will be constructed using the basic principles of a box plot.This ensures that data classification is not manipulated, and that the data is visualised accurately to represent the real-world situation. The box map will enable statistical interpretation of outliers and better identification of subzones that have relatively higher or lower demand compared to the rest of the subzones. In this analysis, data points will be considered outliers if they are more than 1.5 times interquartile range.

The following code chunks are functions to construct the box map.

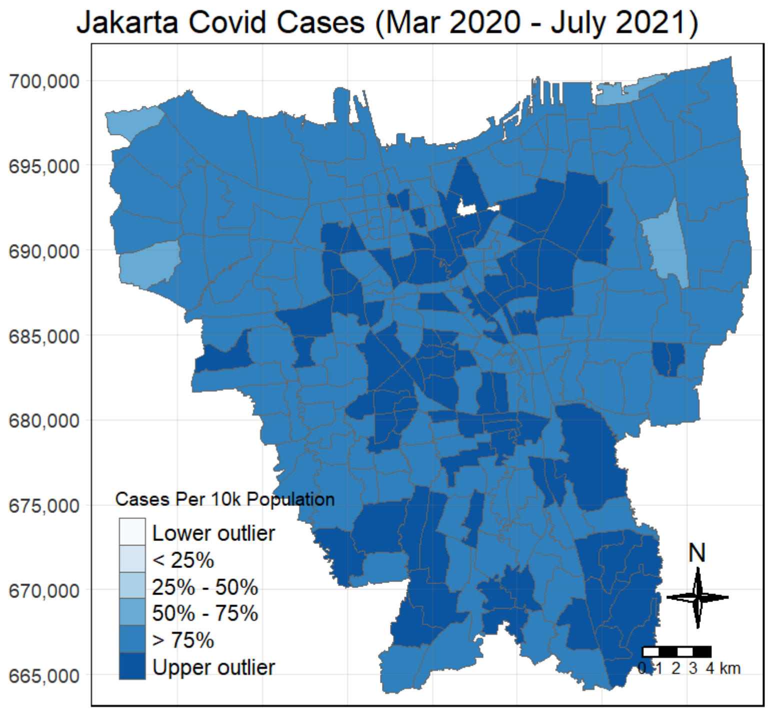
```
# To create break points for box map

boxbreaks <- function ( v , mult = 1.5 ) {
  qv <- unname ( quantile ( v ) )
  iqr <- qv [ 4 ] - qv [ 2
]
  # upfence and lofence define the area where points will be defined as outliers
  upfence <- qv [ 4 ] + mult *
iqr
  lofence <- qv [ 2 ] - mult *
iqr
  # initialize break points vector
  bb <- vector ( mode= "numeric",length= 7 )
  # logic for lower and upper fences
  if ( lofence < qv [ 1 ] ) {
# no lower outliers
  bb [ 1 ] <- lofence
  bb [ 2 ] <- floor ( qv [ 1
] )
  } else {
  bb [ 2 ] <- lofence
  bb [ 1 ] <- qv [ 1 ]
  }
  if ( upfence > qv [ 5 ] ) {
# no upper outliers
  bb [ 7 ] <- upfence
  bb [ 6 ] <- ceiling ( qv [ 5
] )
  } else {
  bb [ 6 ] <- upfence
  bb [ 7 ] <- qv [ 5 ]
  }
  bb [ 3 : 5 ] <- qv [ 2
: 4 ]

  return ( bb )
```

```
}


# Extract variable as vector out of dataframe
get.var    <-          function (          vname     , df         )          {
  v          <-          df         [          vname     ]          # %>% sf::st_set_geometry(NULL)
  v          <-          unlist     (          v          )          # unname(v[,1])
  return    (          v          )
}


# Boxmap function
boxmap     <-          function (          vnam      , df         , mtitle    , legtitle =
NA         , mult      =          1.5       , palette   =          '-RdBu'        )          {
  df1        <-          drop_na    (          df         )
  var        <-          get.var    (          vnam      ,df1       )
  bb         <-          boxbreaks(          var        )
  tm_shape (          df         )          +
    tm_fill  (          vnam      ,
           title=         legtitle ,
           breaks=         bb        ,
           palette=         "Blues"   ,
           labels =          c          (          "Lower outlier"   , "< 25%"       , "25% - 50%"   ,
"50% - 75%"   ,"> 75%"       , "Upper outlier"   )          )          +
  tm_borders(          lwd=          0.1       , alpha=          1          )          +
  tm_layout(          main.title =          mtitle    ,
           main.title.position =          'center' ,
           main.title.size =          1          ,
           frame =          TRUE      ,legend.title.size =          0.70      , legend.position
=          c          (          "left"    , "bottom" )          )          +
  tm_compass(          type=          "4star"   , size =          2          )          +
  tm_scale_bar(          width =          0.10      )          +
  tm_grid   (          lwd =          0.1       , alpha =          0.2       )          +
  tm_borders(          alpha =          0.5       )
}


# Boxmap function with points overlayed on top of choropleth map
boxmap_pts <-          function (          vnam      , df         , pointdf   , mtitle    , legtitle
=          NA         , mult      =          1.5       , palette   =          '-RdBu'        )
{
  boxmap    (          vnam      , df         , mtitle    , legtitle=         legtitle , mult=
mult      , palette=          palette   )          +
  tm_shape (          pointdf   )          +
    tm_dots  (          col=          "gray23" )
}
```

We will now use the function using the previous constructed dataframe, Jakarta_Covid_Cases to display summary statistics.

```
Covid_Cases_Boxmap <-          boxmap    (          "Cases Per 10k Population", Jakarta_Covid_Cases,
```

```
mtitle=        "Jakarta Covid Cases (Mar 2020 - July 2021)")
Covid_Cases_Boxmap
```



- In line with the previous observation, the upper outlier lies mainly in the region of central Jakarta

#12.3 Case Fatality Ratio (CFR)

Case Fatality Ratio (CFR) estimates the proportion of deaths among identified confirmed cases.To verify one of the earlier stated hypothesis that Covid-19 have low fatality rate, we will use the following formula:

$$Case\ Fatality\ Rate\ = \frac{Total\ no\ of\ Covid-19\ Death\ at\ Sub-District\ Level}{Total\ Covid-19\ Cases\ of\ the\ Sub-District} * 100$$

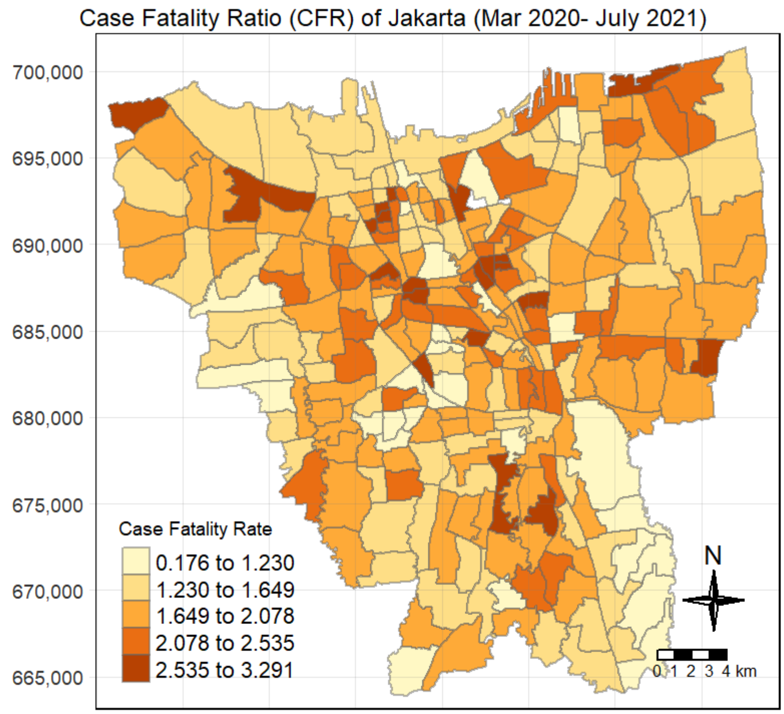
The case fatality rate represents the proportion of cases that eventually die from a disease.

We will create a new dataframe called Merged_DF to calculate the CFR.

```
Merged_DF <-        Covid_DF  %>%       select    (         'Cases'   , 'Sub_District','Death'
)

Merged_DF<-        left_join(        DKI_Jakarta, Merged_DF, by=          c         (
"Sub_District" =         "Sub_District")         )          %>%         group_by   (
Sub_District)          %>%        dplyr    ::        summarise(        `Case Fatality Rate`
=          (         sum        (          Death      )          /          (          sum       (
Cases     )          )          )          *         100        )          %>%         ungroup   (
)
```

Next, we will plot the result on the map using jenks classification method

```
tmap_mode(        "plot"    )        +
  tm_shape (        Merged_DF)        +
  tm_fill  (        "Case Fatality Rate",n =         5        , style=        "jenks"  ,
          legend.is.portrait =         TRUE      )        +
  tm_borders(        alpha =         0.5      )        +
  tm_layout(        main.title =
"Case Fatality Ratio (CFR) of Jakarta (Mar 2020- July 2021) ",
            main.title.position =         "center" ,
            main.title.size =         0.75     ,title.size =         0.30     ,legend.title.size
=         0.70     ,
            legend.outside =         FALSE    ,
            legend.position =         c        (        "left"   , "bottom" )        ,
            frame =         TRUE      )        +
  tm_compass(        type=        "4star"  , size =         2        )        +
  tm_scale_bar(        width =         0.10     )        +
  tm_grid  (        lwd =         0.1      , alpha =         0.2      )
```



- From the result, there appears to be difference in case fatality rate across sub-district in Jakarta
- In line with earlier observation, CFR appears to be higher in Central Jakarta region

#12.4 Localised Geospatial Statistic

```
Jakarta_Covid_Cases_sp <-        as        (        Jakarta_Covid_Cases, 'Spatial')
Jakarta_Covid_Cases_sp
```

```
class       : SpatialPolygonsDataFrame
features    : 4176
extent      : -3644275, -3606237, 663887.8, 701380.1  (xmin, xmax, ymin, ymax)
crs         : +proj=tmerc +lat_0=0 +lon_0=139.5 +k=0.9999 +x_0=200000 +y_0=1500000 +ellps=WGS84 +towg
```

```
crs          : +proj=tmerc +lat_0=0 +lon_0=139.5 +k=0.9999 +x_0=200000 +y_0=1300000 +ellps=WGS84 +towg
variables    : 11
names        :  Sub_District,  Date, Cases.Per.10k.Population, Object_ID, Village_Code,       Village,
min values   :        ANCOL, 18352,                        0,     25384,   3171011001,          ANCOL,
max values   : WIJAYA KUSUMA, 18839,          3808.29015544041,     25644,   3175101008, WIJAYA KUSUMA,
```

```
JK_Covid <- poly2nb(Jakarta_Covid_Cases_sp, queen=FALSE)
```

```
wm_queen <- poly2nb(Jakarta_Covid_Cases_sp, queen=TRUE)
summary(wm_queen)
```

```
Neighbour list object:
Number of regions: 4176
Number of nonzero links: 443568
Percentage nonzero weights: 2.543544
Average number of links: 106.2184
Link number distribution:

  47   63   79   95  111  127  143  159  191
  80  176  720  912 1088  640  400  144   16
80 least connected regions:
545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 1393 1394 1395 1396 1397 1398 1399 14
16 most connected regions:
1745 1746 1747 1748 1749 1750 1751 1752 1753 1754 1755 1756 1757 1758 1759 1760 with 191 links
```

```
print(paste0('Rook contiguity: There are ', length(which(card(JK_Covid) == 0)),
' municipalities with no neighbours.'))
```

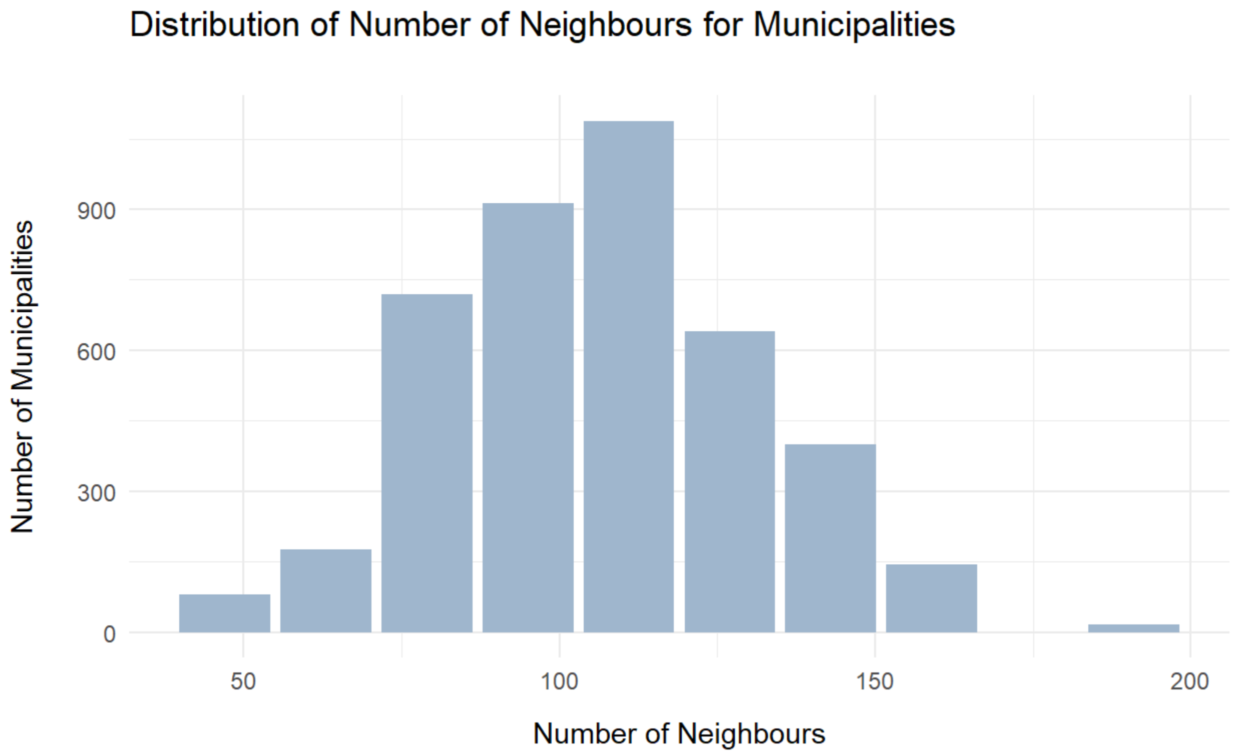
```
[1] "Rook contiguity: There are 0 municipalities with no neighbours."
```

```
print(paste0('Queen contiguity: There are ', length(which(card(wm_queen) == 0)),
' municipalities with no neighbours.'))
```

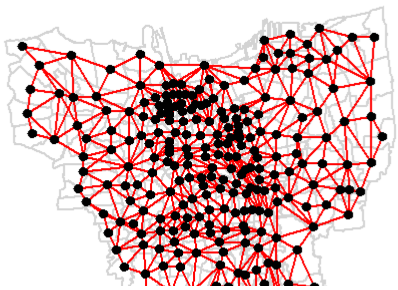
```
[1] "Queen contiguity: There are 0 municipalities with no neighbours."
```

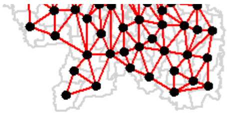
```
# Create data frame using neighbour list for queen contiguity weight matrix.
# For each number of neighbour, count the number of municipalities having that number of
neighbouring municipalities
queen_df <- data.frame('Neighbours' = card(wm_queen)) %>%
  group_by(Neighbours) %>%
  dplyr::summarise(Count = n())
queen_df[is.na(queen_df)] = 0

# Create bar chart visualising the distribution of number of neighbours
ggplot(queen_df, aes(x = Neighbours, y = Count)) +
  geom_col(fill = 'slategray3') +
```

```
  labs    (     title =     'Distribution of Number of Neighbours for Municipalities',
       x =     'Number of Neighbours',
       y =     'Number of Municipalities')     +
  theme_minimal(     )     +
  theme    (     axis.title.y =     element_text(     margin =     margin
(     t =     0     , r =     15     , b =     0     , l =
0     )     )     ,
        axis.title.x =     element_text(     margin =     margin     (     t
=     10     , r =     0     , b =     0     , l =     0     )
)     ,
        plot.title =     element_text(     margin =     margin     (     t =
0     , r =     0     , b =     20     , l =     0     )     )
)
```




```
plot    (     Jakarta_Covid_Cases_sp, border=     "lightgrey")
plot    (     wm_queen , coordinates(     Jakarta_Covid_Cases_sp)     , pch =
19     , cex =     0.6     , add =     TRUE     , col=     "red"     )
```





#10.1.9 Relative Risk Map