Point Pattern Analysis (Density\_Based)

Afiq

2023-03-20

library(writexl)  
library(readxl)  
library(sf)

## Linking to GEOS 3.9.3, GDAL 3.5.2, PROJ 8.2.1; sf\_use\_s2() is TRUE

library(ggplot2)

## Warning: package 'ggplot2' was built under R version 4.2.3

library(rgdal)

## Loading required package: sp

## Please note that rgdal will be retired during 2023,  
## plan transition to sf/stars/terra functions using GDAL and PROJ  
## at your earliest convenience.  
## See https://r-spatial.org/r/2022/04/12/evolution.html and https://github.com/r-spatial/evolution  
## rgdal: version: 1.6-3, (SVN revision 1187)  
## Geospatial Data Abstraction Library extensions to R successfully loaded  
## Loaded GDAL runtime: GDAL 3.5.2, released 2022/09/02  
## Path to GDAL shared files: C:/Users/ACER/AppData/Local/R/win-library/4.2/rgdal/gdal  
## GDAL binary built with GEOS: TRUE   
## Loaded PROJ runtime: Rel. 8.2.1, January 1st, 2022, [PJ\_VERSION: 821]  
## Path to PROJ shared files: C:/Users/ACER/AppData/Local/R/win-library/4.2/rgdal/proj  
## PROJ CDN enabled: FALSE  
## Linking to sp version:1.5-1  
## To mute warnings of possible GDAL/OSR exportToProj4() degradation,  
## use options("rgdal\_show\_exportToProj4\_warnings"="none") before loading sp or rgdal.

library(here)

## here() starts at C:/Users/ACER/Documents/Spatial-Analysis-HFMD

library(tmap)  
library(dplyr)

## Warning: package 'dplyr' was built under R version 4.2.3

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

library(spatstat)

## Loading required package: spatstat.data

## Loading required package: spatstat.geom

## spatstat.geom 3.0-3

## Loading required package: spatstat.random

## spatstat.random 3.0-1

## Loading required package: spatstat.explore

## Loading required package: nlme

##   
## Attaching package: 'nlme'

## The following object is masked from 'package:dplyr':  
##   
## collapse

## spatstat.explore 3.0-5

## Loading required package: spatstat.model

## Loading required package: rpart

## spatstat.model 3.0-2

## Loading required package: spatstat.linnet

## spatstat.linnet 3.0-3

##   
## spatstat 3.0-2   
## For an introduction to spatstat, type 'beginner'

library(tidyverse)

## ── Attaching packages  
## ───────────────────────────────────────  
## tidyverse 1.3.2 ──

## ✔ tibble 3.2.1 ✔ purrr 1.0.1  
## ✔ tidyr 1.3.0 ✔ stringr 1.5.0  
## ✔ readr 2.1.3 ✔ forcats 0.5.2

## Warning: package 'tibble' was built under R version 4.2.3

## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ nlme::collapse() masks dplyr::collapse()  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()

library (RColorBrewer)

# Load HFMD Data

HFMD\_overall <- read\_excel( here("Density Based Analysis",  
 "HFMD\_17\_22.xlsx"))  
HFMD\_overall <- st\_as\_sf(HFMD\_overall,coords = c("X\_LONGITUDE","X\_LATITUDE"),   
 crs = 4326)  
HFMD\_overall <- st\_transform(HFMD\_overall, 3168)  
Penang <- st\_read(here("Penang",   
 "mukim2000\_penang1.shp"))

## Reading layer `mukim2000\_penang1' from data source   
## `C:\Users\ACER\Documents\Spatial-Analysis-HFMD\Penang\mukim2000\_penang1.shp'   
## using driver `ESRI Shapefile'  
## Simple feature collection with 83 features and 4 fields  
## Geometry type: MULTIPOLYGON  
## Dimension: XY  
## Bounding box: xmin: 243501.5 ymin: 567201.1 xmax: 285076.2 ymax: 618503.2  
## CRS: NA

#View Data

st\_crs(Penang)<-3168  
st\_crs(Penang)

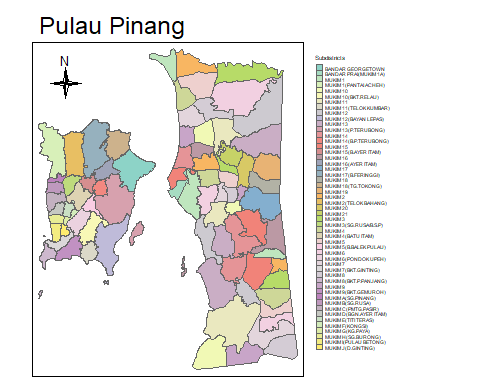
## Coordinate Reference System:  
## User input: EPSG:3168   
## wkt:  
## PROJCRS["Kertau (RSO) / RSO Malaya (m)",  
## BASEGEOGCRS["Kertau (RSO)",  
## DATUM["Kertau (RSO)",  
## ELLIPSOID["Everest 1830 (RSO 1969)",6377295.664,300.8017,  
## LENGTHUNIT["metre",1]]],  
## PRIMEM["Greenwich",0,  
## ANGLEUNIT["degree",0.0174532925199433]],  
## ID["EPSG",4751]],  
## CONVERSION["Rectified Skew Orthomorphic Malaya Grid (metres)",  
## METHOD["Hotine Oblique Mercator (variant A)",  
## ID["EPSG",9812]],  
## PARAMETER["Latitude of projection centre",4,  
## ANGLEUNIT["degree",0.0174532925199433],  
## ID["EPSG",8811]],  
## PARAMETER["Longitude of projection centre",102.25,  
## ANGLEUNIT["degree",0.0174532925199433],  
## ID["EPSG",8812]],  
## PARAMETER["Azimuth of initial line",323.0257905,  
## ANGLEUNIT["degree",0.0174532925199433],  
## ID["EPSG",8813]],  
## PARAMETER["Angle from Rectified to Skew Grid",323.130102361111,  
## ANGLEUNIT["degree",0.0174532925199433],  
## ID["EPSG",8814]],  
## PARAMETER["Scale factor on initial line",0.99984,  
## SCALEUNIT["unity",1],  
## ID["EPSG",8815]],  
## PARAMETER["False easting",804670.24,  
## LENGTHUNIT["metre",1],  
## ID["EPSG",8806]],  
## PARAMETER["False northing",0,  
## LENGTHUNIT["metre",1],  
## ID["EPSG",8807]]],  
## CS[Cartesian,2],  
## AXIS["(E)",east,  
## ORDER[1],  
## LENGTHUNIT["metre",1]],  
## AXIS["(N)",north,  
## ORDER[2],  
## LENGTHUNIT["metre",1]],  
## USAGE[  
## SCOPE["Engineering survey, topographic mapping."],  
## AREA["Malaysia - West Malaysia onshore."],  
## BBOX[1.21,99.59,6.72,104.6]],  
## ID["EPSG",3168]]

glimpse(HFMD\_overall)

## Rows: 15,586  
## Columns: 12  
## $ CASE\_ID <chr> "Case 1", "Case 2", "Case 3", "Case 4", "Case 5", "Case …  
## $ YEAR <dbl> 2018, 2018, 2018, 2018, 2018, 2018, 2018, 2019, 2019, 20…  
## $ MONTH <chr> "October", "August", "July", "July", "July", "November",…  
## $ WEEK <dbl> 44, 32, 27, 28, 28, 44, 38, 14, 3, 11, 12, 8, 2, 13, 11,…  
## $ AGE <dbl> 1, 1, 3, 1, 2, 5, 4, 4, 5, 2, 4, 4, 1, 1, 1, 3, 1, 5, 1,…  
## $ RACE <chr> "Cina", "Melayu", "Melayu", "Melayu", "Melayu", "Cina", …  
## $ GENDER <chr> "Lelaki", "Lelaki", "Perempuan", "Perempuan", "Perempuan…  
## $ DAERAH <chr> "Seberang PERAI TENGAH", "Seberang PERAI TENGAH", "Seber…  
## $ ADDRESS <chr> "47 JALAN BUDIMAN 2, TAMAN BUDIMAN BUKIT MERTAJAMPulau P…  
## $ X\_ADDRESS <chr> "47 Jalan Budiman 2, Taman Budiman, Bukit Mertajam, Sebe…  
## $ within\_Penang <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,…  
## $ geometry <POINT [m]> POINT (277266.8 589310.9), POINT (271351.3 594495.…

# Plot HFMD points(2017-2022) in Penang Polygon

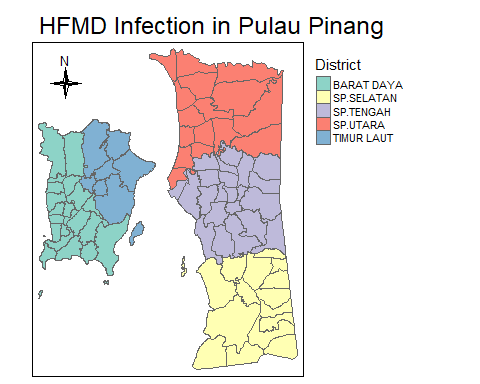
tm\_shape(Penang)+tm\_polygons("NAMMUK", title = "Subdistricts")+ tm\_layout(main.title = "Pulau Pinang")+ tmap\_options(max.categories = 51)+ tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



tm\_shape(Penang)+ tm\_polygons("NAMA\_DP", title = "District")+ tm\_shape(HFMD\_overall) + tm\_dots(size = 0.0,col = "black")+ tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))+tm\_layout(main.title = "HFMD Infection in Pulau Pinang")

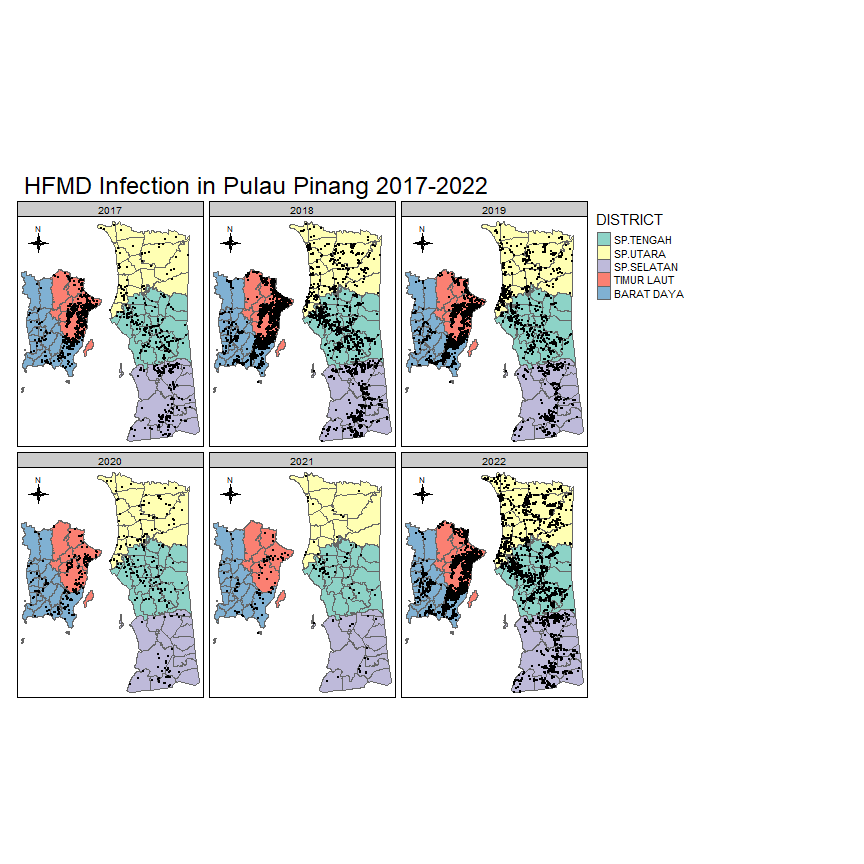
## Warning in max(x, na.rm = TRUE): no non-missing arguments to max; returning -Inf

## Warning in max(symbol.size, na.rm = TRUE): no non-missing arguments to max;  
## returning -Inf



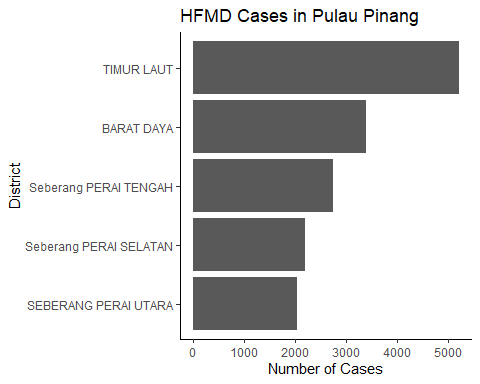
## Plot Yearly HFMD Cases in Pulau Pinang

tm\_shape(Penang) +  
 tm\_polygons("NAMA\_DP",title = "DISTRICT") +   
 tm\_shape(HFMD\_overall) + tm\_layout( legend.outside = TRUE) + tm\_dots(col = "black", size = 0.03 ) +  
 tm\_layout(main.title = "HFMD Infection in Pulau Pinang 2017-2022") + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE) + tm\_compass(type = "4star", size = 2, position = c("left", "top"))



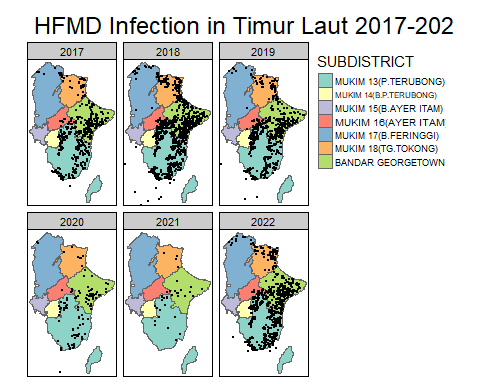
## Plot HFMD points(2017-2022) according to district

#Plot Case According to district  
ggplot(  
 data = HFMD\_overall,  
 mapping = aes (  
 x = fct\_rev(fct\_infreq (DAERAH)))) +  
 geom\_bar() +  
 coord\_flip()+  
 theme\_classic()+  
 labs(  
 x = "District",  
 y = "Number of Cases",  
 title = "HFMD Cases in Pulau Pinang"  
 )



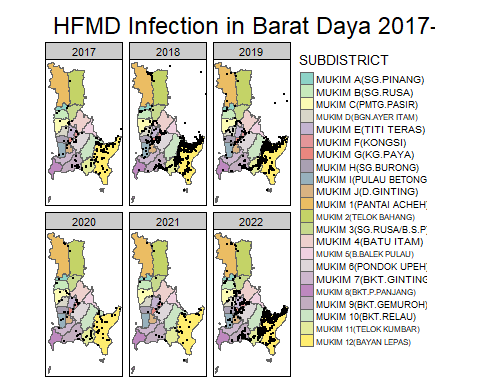
tm\_shape(Penang[Penang$NAMA\_DP == "TIMUR LAUT",])+tm\_layout(main.title = "HFMD Infection in Timur Laut 2017-2022") +  
 tm\_polygons("NAMMUK",title = "SUBDISTRICT") +  
 tm\_shape(HFMD\_overall[HFMD\_overall$DAERAH == "TIMUR LAUT",])+tm\_dots (col = "black")+tm\_layout(legend.outside = TRUE) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE)

## Legend labels were too wide. The labels have been resized to 0.54, 0.50, 0.55, 0.60, 0.58, 0.57, 0.53. Increase legend.width (argument of tm\_layout) to make the legend wider and therefore the labels larger.

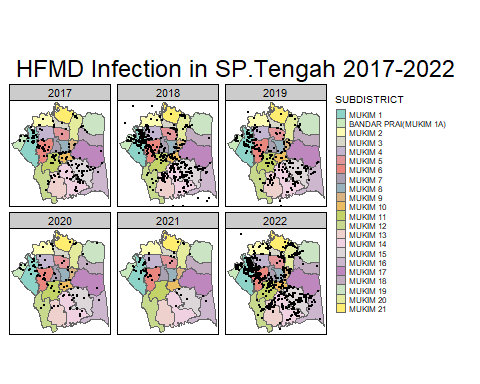


tm\_shape(Penang[Penang$NAMA\_DP == "BARAT DAYA",])+  
 tm\_polygons("NAMMUK",title = "SUBDISTRICT")+tm\_layout(main.title = "HFMD Infection in Barat Daya 2017-2022") +  
 tm\_shape(HFMD\_overall[HFMD\_overall$DAERAH == "BARAT DAYA",])+tm\_dots (col = "black")+tm\_layout(legend.outside = TRUE) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE)

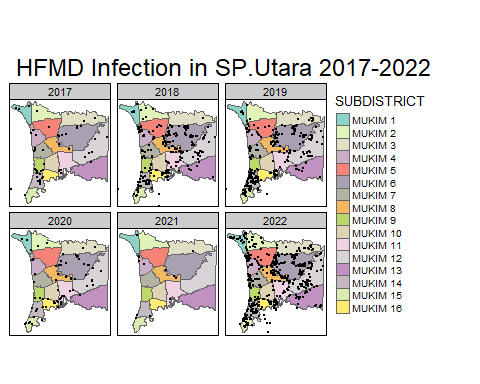
## Some legend labels were too wide. These labels have been resized to 0.58, 0.51, 0.59, 0.53, 0.53, 0.51, 0.53, 0.51, 0.53, 0.59, 0.51, 0.53, 0.59, 0.49, 0.52. Increase legend.width (argument of tm\_layout) to make the legend wider and therefore the labels larger.



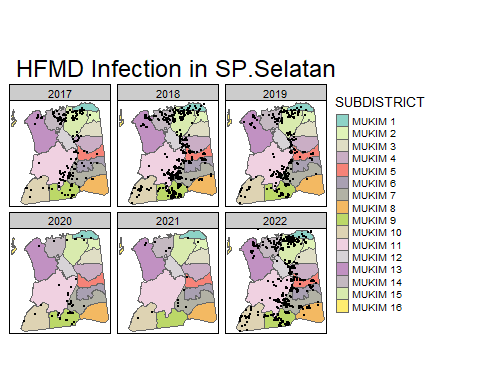
tm\_shape(Penang[Penang$NAMA\_DP == "SP.TENGAH",])+  
 tm\_polygons("NAMMUK",title = "SUBDISTRICT")+tm\_layout(main.title = "HFMD Infection in SP.Tengah 2017-2022") +  
 tm\_shape(HFMD\_overall[HFMD\_overall$DAERAH == "Seberang PERAI TENGAH",])+tm\_dots (col = "black")+tm\_layout(legend.outside = TRUE) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE)



tm\_shape(Penang[Penang$NAMA\_DP == "SP.UTARA",])+  
 tm\_polygons("NAMMUK",title = "SUBDISTRICT")+tm\_layout(main.title = "HFMD Infection in SP.Utara 2017-2022") +  
 tm\_shape(HFMD\_overall[HFMD\_overall$DAERAH == "SEBERANG PERAI UTARA",])+tm\_dots (col = "black")+tm\_layout(legend.outside = TRUE) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE)



tm\_shape(Penang[Penang$NAMA\_DP == "SP.SELATAN",])+  
 tm\_polygons("NAMMUK",title = "SUBDISTRICT")+ tm\_layout(main.title = "HFMD Infection in SP.Selatan")+  
 tm\_shape(HFMD\_overall[HFMD\_overall$DAERAH == "Seberang PERAI SELATAN",])+tm\_dots (col = "black")+tm\_layout(legend.outside = TRUE) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE)



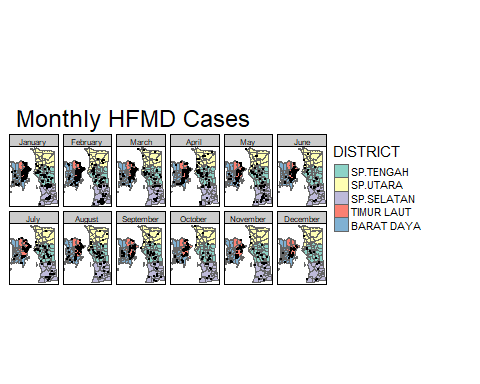
## Plot Monthly HFMD Cases in Pulau Pinang

### 1.Convert “MONTH” variable to factor with ordered levels

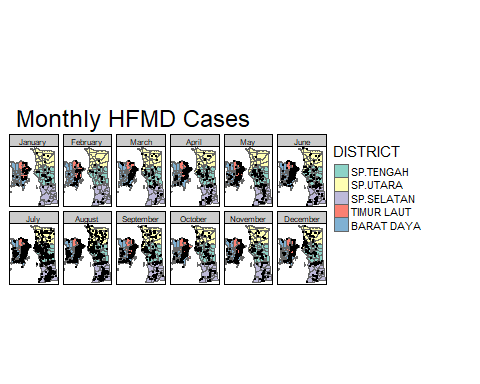
HFMD\_overall$MONTH <- factor(HFMD\_overall$MONTH,   
 levels = month.name,   
 ordered = TRUE)

#### Plotting monthly HFMD Map

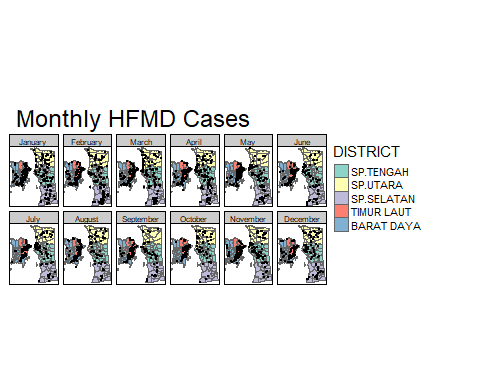
tm\_shape(Penang) +   
 tm\_polygons("NAMA\_DP", title = "DISTRICT") +   
 tm\_layout(main.title = "Monthly HFMD Cases")+  
 tm\_shape(HFMD\_overall) +  
 tm\_layout( legend.outside = TRUE) +   
 tm\_dots(col = "black", size = 0.03 ) +   
 tm\_facets("MONTH", "YEAR",nrow = 2, ncol = 6, as.layers = TRUE)



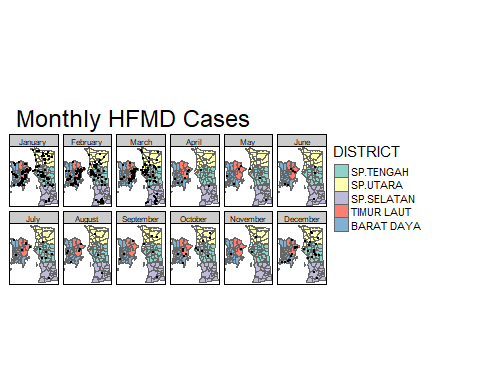
## ===========================



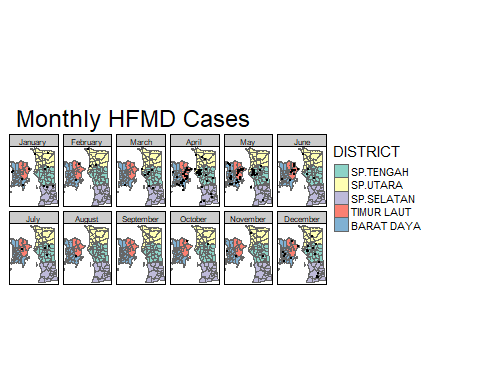
## =============



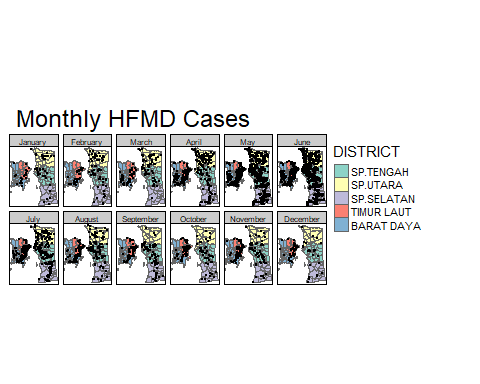
## =============



## ==============



## =============



# Incidence of HFMD in Pulau Pinang

# 1.Prepare Data

# 2.count point in each Mukim

Overall\_Coor <- HFMD\_overall [,c('geometry','YEAR','DAERAH')]  
Overall\_Coor <- na.omit(Overall\_Coor)

intersection\_overall <- st\_intersection(x=Penang,y=Overall\_Coor)

## Warning: attribute variables are assumed to be spatially constant throughout all  
## geometries

count\_HFMD\_Mukim\_Overall <- intersection\_overall %>% count (YEAR,NAMA\_DP,NAMMUK,PENDUDUK)

# 3.Load population data

Gen\_pop <- read\_excel(here("Density Based Analysis",  
 "Gen\_Pop.xlsx"))

# 4.calculate incidence

HFMD\_Penang\_Overall <- merge(count\_HFMD\_Mukim\_Overall,Gen\_pop, by = c("YEAR", "NAMA\_DP","NAMMUK") , all=TRUE)  
Overall\_Incidence <- HFMD\_Penang\_Overall %>% mutate(Incidence\_1000 = (n/PENDUDUK\_L)\*1000)

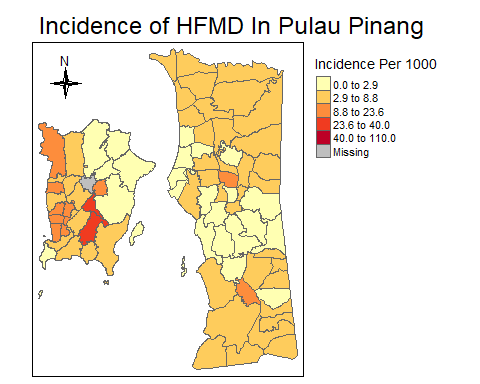
# 5. Merge Penang and HFMD Incidence Data

HFMD\_Penang\_Overall\_Incidence <- st\_join(Penang, Overall\_Incidence)  
glimpse(HFMD\_Penang\_Overall\_Incidence)

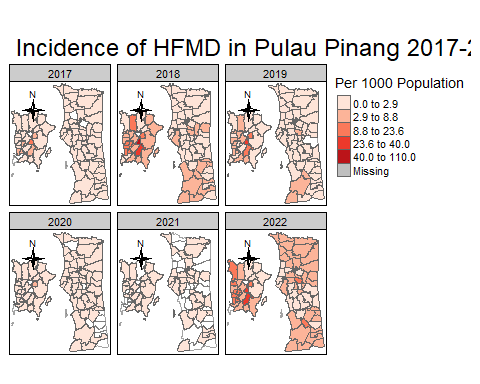
## Rows: 443  
## Columns: 12  
## $ NAMA\_NG <chr> "PULAU PINANG", "PULAU PINANG", "PULAU PINANG", "PULAU …  
## $ NAMA\_DP.x <chr> "SP.TENGAH", "SP.TENGAH", "SP.TENGAH", "SP.TENGAH", "SP…  
## $ NAMMUK.x <chr> "MUKIM 1", "MUKIM 1", "MUKIM 1", "MUKIM 1", "MUKIM 1", …  
## $ PENDUDUK.x <dbl> 42653, 42653, 42653, 42653, 42653, 42653, 12644, 12644,…  
## $ YEAR <dbl> 2017, 2018, 2019, 2020, 2021, 2022, 2017, 2018, 2019, 2…  
## $ NAMA\_DP.y <chr> "SP.TENGAH", "SP.TENGAH", "SP.TENGAH", "SP.TENGAH", "SP…  
## $ NAMMUK.y <chr> "MUKIM 1", "MUKIM 1", "MUKIM 1", "MUKIM 1", "MUKIM 1", …  
## $ PENDUDUK.y <dbl> 42653, 42653, 42653, 42653, 42653, 42653, 12644, 12644,…  
## $ n <int> 29, 128, 87, 26, 25, 194, 7, 22, 17, 5, 1, 41, 7, 13, 3…  
## $ PENDUDUK\_L <dbl> 44300, 44100, 44000, 43800, 43800, 43800, 15900, 15900,…  
## $ Incidence\_1000 <dbl> 0.6546275, 2.9024943, 1.9772727, 0.5936073, 0.5707763, …  
## $ geometry <MULTIPOLYGON [m]> MULTIPOLYGON (((269049.6 59..., MULTIPOLYG…

# 6.Plot HFMD Incidence in Pulau Pinang (Overall)

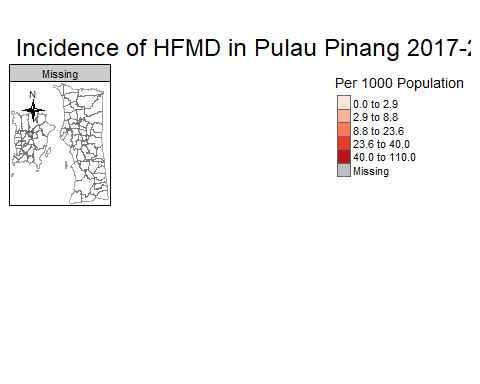
tm\_shape(Penang) + tm\_borders(alpha=.6) + tm\_shape(HFMD\_Penang\_Overall\_Incidence) + tm\_polygons("Incidence\_1000",style = "jenks", palette = brewer.pal(5, "YlOrRd"), range = c(0, 1000),title = "Incidence Per 1000") +tm\_layout( legend.outside = TRUE) + tm\_layout(main.title = "Incidence of HFMD In Pulau Pinang")+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))

 # 7.Plot Yearly Incidence Rate of HFMD in Pulau Pinang

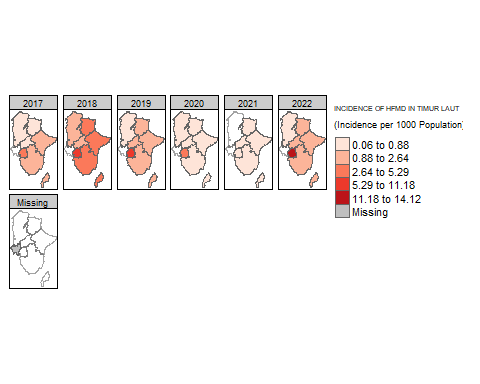
tm\_shape(Penang) + tm\_borders(alpha=.6) + tm\_shape(HFMD\_Penang\_Overall\_Incidence) + tm\_polygons("Incidence\_1000",style = "jenks", title = "Per 1000 Population", palette = "Reds", range = c(0, 1000)) + tm\_facets("YEAR", nrow = 2, ncol = 3, as.layers = TRUE) +tm\_layout(main.title = "Incidence of HFMD in Pulau Pinang 2017-2022") +tm\_compass(type = "4star", size = 2, position = c("left", "top"))



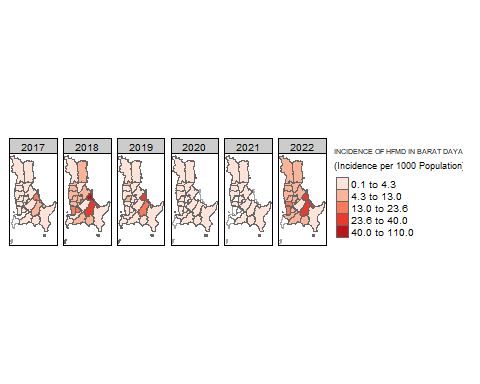
## ================================================================================

 # 8. Yearly incidence according to district in Pulau Pinang # Timur Laut

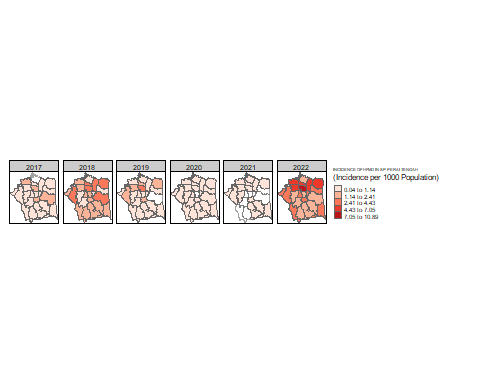
tm\_shape(Penang[Penang$NAMA\_DP == "TIMUR LAUT", ])+ tm\_borders(alpha=.6) +  
tm\_shape(HFMD\_Penang\_Overall\_Incidence[HFMD\_Penang\_Overall\_Incidence$ NAMA\_DP.x== "TIMUR LAUT",])+tm\_polygons("Incidence\_1000",style = "jenks", title = "(Incidence per 1000 Population)", palette = "Reds") + tm\_facets("YEAR", ncol = 6, as.layers = TRUE)+tm\_layout(title = "INCIDENCE OF HFMD IN TIMUR LAUT",title.size=1)+ tm\_layout(legend.outside = TRUE)

 # Barat Daya

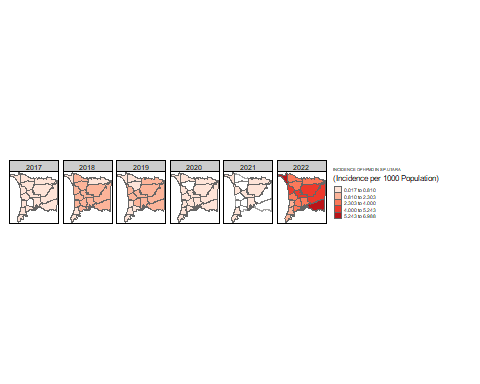
tm\_shape(Penang[Penang$NAMA\_DP == "BARAT DAYA", ])+ tm\_borders(alpha=.6) +  
tm\_shape(HFMD\_Penang\_Overall\_Incidence[HFMD\_Penang\_Overall\_Incidence$ NAMA\_DP.x== "BARAT DAYA",])+tm\_polygons("Incidence\_1000",style = "jenks", title = "(Incidence per 1000 Population)", palette = "Reds") + tm\_facets("YEAR", ncol = 6, as.layers = TRUE)+tm\_layout(title = "INCIDENCE OF HFMD IN BARAT DAYA",title.size=1)+ tm\_layout(legend.outside = TRUE)

 # SP Tengah

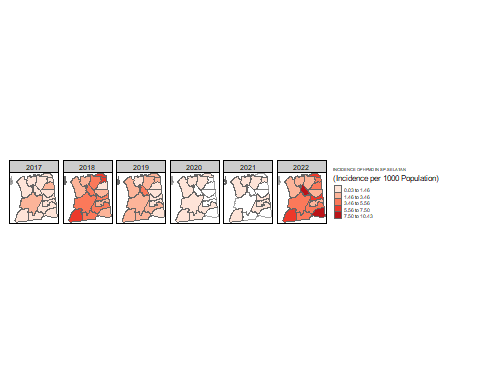
tm\_shape(Penang[Penang$NAMA\_DP == "SP.TENGAH", ])+ tm\_borders(alpha=.6) +  
tm\_shape(HFMD\_Penang\_Overall\_Incidence[HFMD\_Penang\_Overall\_Incidence$ NAMA\_DP.x== "SP.TENGAH",])+tm\_polygons("Incidence\_1000",style = "jenks", title = "(Incidence per 1000 Population)", palette = "Reds") + tm\_facets("YEAR", ncol = 6, as.layers = TRUE)+tm\_layout(title = "INCIDENCE OF HFMD IN SP.PERAI TENGAH",title.size=1)+ tm\_layout(legend.outside = TRUE)

 # SP Utara

tm\_shape(Penang[Penang$NAMA\_DP == "SP.UTARA", ])+ tm\_borders(alpha=.6) +  
tm\_shape(HFMD\_Penang\_Overall\_Incidence[HFMD\_Penang\_Overall\_Incidence$ NAMA\_DP.x== "SP.UTARA",])+tm\_polygons("Incidence\_1000",style = "jenks", title = "(Incidence per 1000 Population)", palette = "Reds") + tm\_facets("YEAR", ncol = 6, as.layers = TRUE)+tm\_layout(title = "INCIDENCE OF HFMD IN SP.UTARA",title.size=1)+ tm\_layout(legend.outside = TRUE)

 # SP Selatan

tm\_shape(Penang[Penang$NAMA\_DP == "SP.SELATAN", ])+ tm\_borders(alpha=.6) +  
tm\_shape(HFMD\_Penang\_Overall\_Incidence[HFMD\_Penang\_Overall\_Incidence$ NAMA\_DP.x== "SP.SELATAN",])+tm\_polygons("Incidence\_1000",style = "jenks", title = "(Incidence per 1000 Population)", palette = "Reds") + tm\_facets("YEAR", ncol = 6, as.layers = TRUE)+tm\_layout(title = "INCIDENCE OF HFMD IN SP.SELATAN",title.size=1)+ tm\_layout(legend.outside = TRUE)

 # Density Based Analysis using Kernel Density Estimates (KDE) # Rescale and load point feature into Penang.owin #Move coordinate to first column

HFMD\_overall <- HFMD\_overall[, c("geometry", names(HFMD\_overall)[-which(names(HFMD\_overall) == "geometry")])]

#Create owin data for Penang

Penang.owin <- as.owin(Penang)  
Penang.owin.km <- rescale(Penang.owin, 1000)

#Load point feature shapefile into Penang.owin

HFMD\_overall.ppp <- as.ppp(HFMD\_overall)

## Warning in as.ppp.sf(HFMD\_overall): only first attribute column is used for  
## marks

marks(HFMD\_overall.ppp) <- NULL  
HFMD\_overall.ppp <- rescale(HFMD\_overall.ppp, 1000,"km")  
Window(HFMD\_overall.ppp) <- Penang.owin.km

#Kernel Density Estimates (KDE) Pulau Pinang

HFMD\_overall.density <- density(HFMD\_overall.ppp, sigma=1)   
class(HFMD\_overall.density)

## [1] "im"

#Rasterize the KDE image using package raster

library(raster)

##   
## Attaching package: 'raster'

## The following object is masked from 'package:nlme':  
##   
## getData

## The following object is masked from 'package:dplyr':  
##   
## select

library(viridis)

## Loading required package: viridisLite

library(leaflet)

HFMD\_overall.density.raster <- raster(HFMD\_overall.density)

#Change the extent of the rasterlayer #1.define intended extend objects using Kelantan polygon

xmin= 243501.5   
xmax= 285076.2  
ymin= 567201.1   
ymax= 618503.2

#2.grab the cols and rows for the raster using @ncols and @nrows

HFMD\_overall.density.raster @ncols

## [1] 128

HFMD\_overall.density.raster @nrows

## [1] 128

#3.create a raster extend class

rasExt <- extent(xmin,xmax,ymin,ymax)  
rasExt

## class : Extent   
## xmin : 243501.5   
## xmax : 285076.2   
## ymin : 567201.1   
## ymax : 618503.2

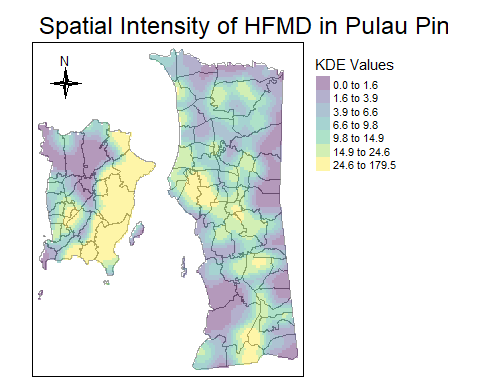
#4.apply the extent to our KDE raster

HFMD\_overall.density.raster@extent <- rasExt

crs(HFMD\_overall.density.raster) <- 3168

## Plot Intensity of HFMD in Pulau Pinang

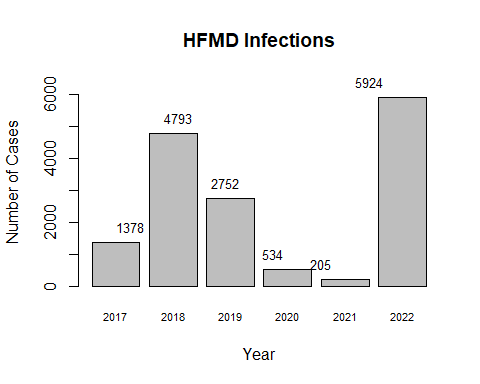
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(HFMD\_overall.density.raster) +   
 tm\_raster(style = "quantile", n = 7 , palette = viridis(7, direction = 1), alpha = .4, title = "KDE Values") + tm\_layout(main.title = "Spatial Intensity of HFMD in Pulau Pinang",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))

 ## KDE intensity by YEAR #Convert “YEAR” variable to factor with ordered levels

HFMD\_overall$YEAR <- factor(HFMD\_overall$YEAR,   
 ordered = TRUE)

#Plot Case vs YEAR

counts <- table(HFMD\_overall$YEAR)  
barplot(counts, main = "HFMD Infections", xlab = "Year",  
 ylab = "Number of Cases", cex.axis = 1, cex.lab = 1, cex.names = 0.7, ylim = c(0, 6500))  
text(x = 1:length(counts), y = counts, labels = counts, pos = 3, cex = 0.8)

 #KDE density for each year

Coor\_Year <- HFMD\_overall[,c(1,3,4)]  
Coor\_Year <- na.omit(Coor\_Year )

#Specified coordinate for male and female

Y2017\_coor <- subset(Coor\_Year, YEAR=='2017')   
Y2018\_coor <- subset(Coor\_Year, YEAR=='2018')   
Y2019\_coor <- subset(Coor\_Year, YEAR=='2019')   
Y2020\_coor <- subset(Coor\_Year, YEAR=='2020')   
Y2021\_coor <- subset(Coor\_Year, YEAR=='2021')   
Y2022\_coor <- subset(Coor\_Year, YEAR=='2022')

#Load a point feature shapefile into Penang.owin

Y2017\_coor.ppp <- as.ppp(Y2017\_coor)

## Warning in as.ppp.sf(Y2017\_coor): only first attribute column is used for marks

marks(Y2017\_coor.ppp ) <- NULL  
Y2017\_coor.ppp <- rescale(Y2017\_coor.ppp , 1000,"km")  
Window(Y2017\_coor.ppp ) <- Penang.owin.km  
Y2018\_coor.ppp <- as.ppp(Y2018\_coor)

## Warning in as.ppp.sf(Y2018\_coor): only first attribute column is used for marks

marks(Y2018\_coor.ppp ) <- NULL  
Y2018\_coor.ppp <- rescale(Y2018\_coor.ppp , 1000,"km")  
Window(Y2018\_coor.ppp ) <- Penang.owin.km  
Y2019\_coor.ppp <- as.ppp(Y2019\_coor)

## Warning in as.ppp.sf(Y2019\_coor): only first attribute column is used for marks

marks(Y2019\_coor.ppp ) <- NULL  
Y2019\_coor.ppp <- rescale(Y2019\_coor.ppp , 1000,"km")  
Window(Y2019\_coor.ppp ) <- Penang.owin.km  
Y2020\_coor.ppp <- as.ppp(Y2020\_coor)

## Warning in as.ppp.sf(Y2020\_coor): only first attribute column is used for marks

marks(Y2017\_coor.ppp ) <- NULL  
Y2020\_coor.ppp <- rescale(Y2020\_coor.ppp , 1000,"km")  
Window(Y2020\_coor.ppp ) <- Penang.owin.km  
Y2021\_coor.ppp <- as.ppp(Y2021\_coor)

## Warning in as.ppp.sf(Y2021\_coor): only first attribute column is used for marks

marks(Y2021\_coor.ppp ) <- NULL  
Y2021\_coor.ppp <- rescale(Y2021\_coor.ppp , 1000,"km")  
Window(Y2021\_coor.ppp ) <- Penang.owin.km  
Y2022\_coor.ppp <- as.ppp(Y2022\_coor)

## Warning in as.ppp.sf(Y2022\_coor): only first attribute column is used for marks

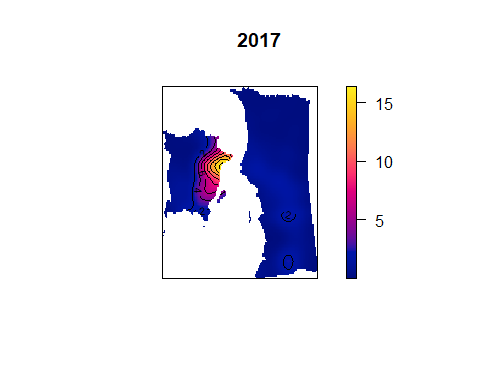
marks(Y2022\_coor.ppp ) <- NULL  
Y2022\_coor.ppp <- rescale(Y2022\_coor.ppp , 1000,"km")  
Window(Y2022\_coor.ppp ) <- Penang.owin.km

#Create Density function for gender (bandwith 2KM)

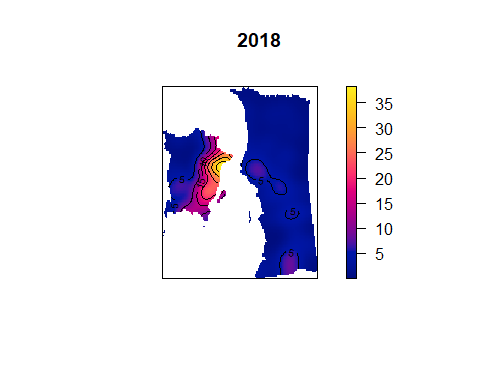
Y2017.coor.density<- density(Y2017\_coor.ppp, sigma=2)   
Y2018.coor.density<- density(Y2018\_coor.ppp, sigma=2)   
Y2019.coor.density<- density(Y2019\_coor.ppp, sigma=2)   
Y2020.coor.density<- density(Y2020\_coor.ppp, sigma=2)   
Y2021.coor.density<- density(Y2021\_coor.ppp, sigma=2)   
Y2022.coor.density<- density(Y2022\_coor.ppp, sigma=2)

#Plot KDE for Yearly Case

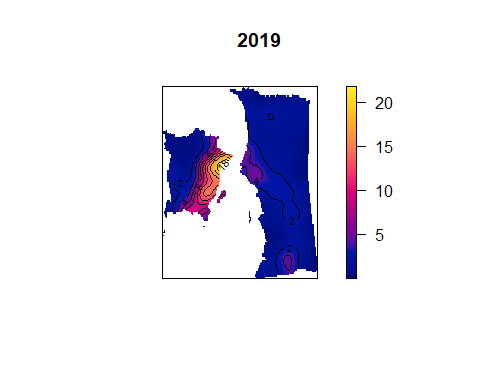
plot(Y2017.coor.density, main = "2017", las = 1)  
contour(Y2017.coor.density, add = TRUE)



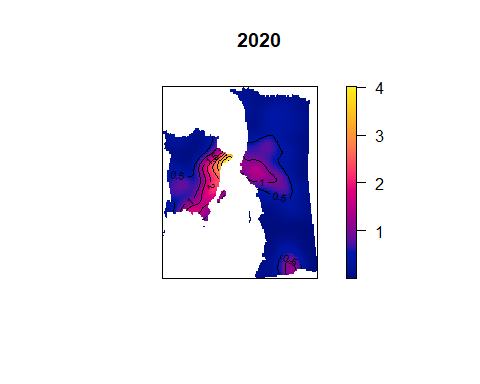
plot(Y2018.coor.density, main = "2018", las = 1)  
contour(Y2018.coor.density, add = TRUE)



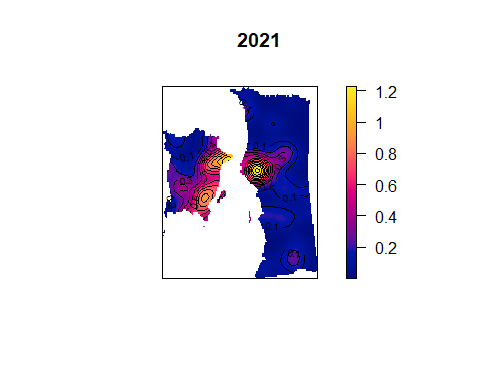
plot(Y2019.coor.density, main = "2019", las = 1)  
contour(Y2019.coor.density, add = TRUE)



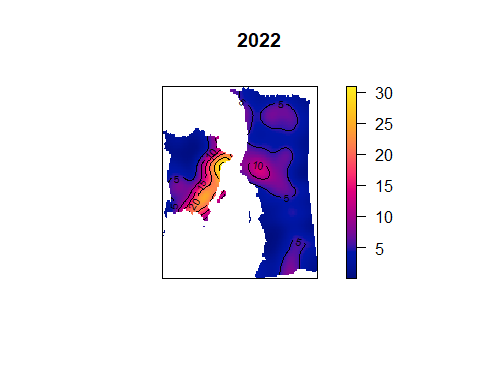
plot(Y2020.coor.density, main = "2020", las = 1)  
contour(Y2020.coor.density, add = TRUE)



plot(Y2021.coor.density, main = "2021", las = 1)  
contour(Y2021.coor.density, add = TRUE)



plot(Y2022.coor.density, main = "2022", las = 1)  
contour(Y2022.coor.density, add = TRUE)

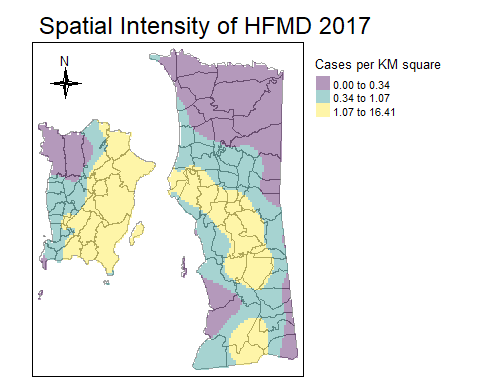


#rasterize KDE image  
Y2017.coor.density.raster <- raster(Y2017.coor.density)  
Y2018.coor.density.raster <- raster(Y2018.coor.density)  
Y2019.coor.density.raster <- raster(Y2019.coor.density)  
Y2020.coor.density.raster <- raster(Y2020.coor.density)  
Y2021.coor.density.raster <- raster(Y2021.coor.density)  
Y2022.coor.density.raster <- raster(Y2022.coor.density)

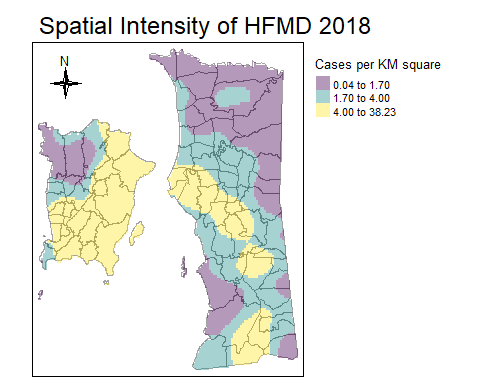
#apply extend to KDE raster  
Y2017.coor.density.raster@extent <- rasExt  
Y2018.coor.density.raster@extent <- rasExt  
Y2019.coor.density.raster@extent <- rasExt  
Y2020.coor.density.raster@extent <- rasExt  
Y2021.coor.density.raster@extent <- rasExt  
Y2022.coor.density.raster@extent <- rasExt

# transform coordinate  
crs (Y2017.coor.density.raster)<- 3168  
crs (Y2018.coor.density.raster)<- 3168  
crs (Y2019.coor.density.raster)<- 3168  
crs (Y2020.coor.density.raster)<- 3168  
crs (Y2021.coor.density.raster)<- 3168  
crs (Y2022.coor.density.raster)<- 3168

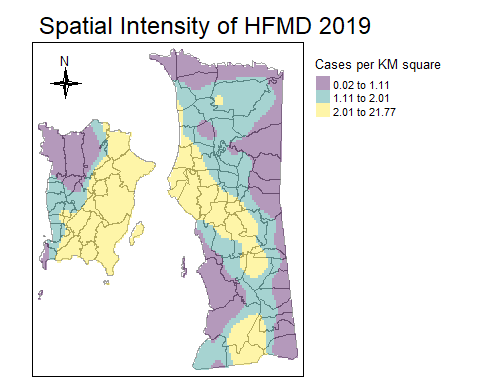
# Plot intensity map  
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2017.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(5, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2017",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



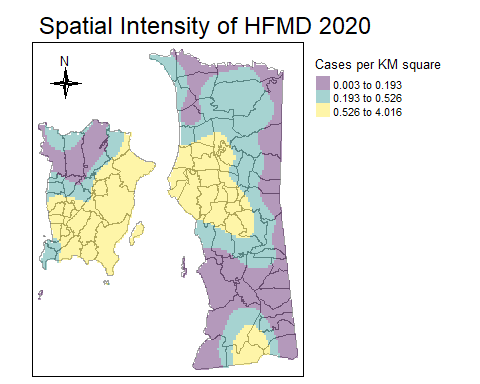
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2018.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(5, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2018",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



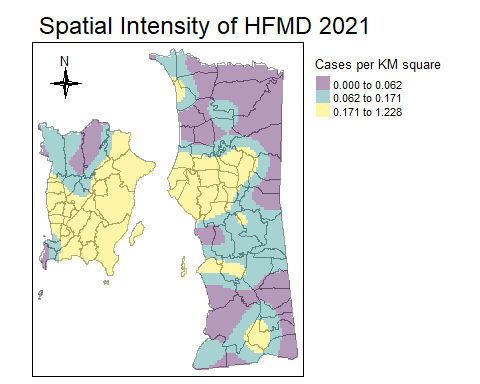
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2019.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(5, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2019",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



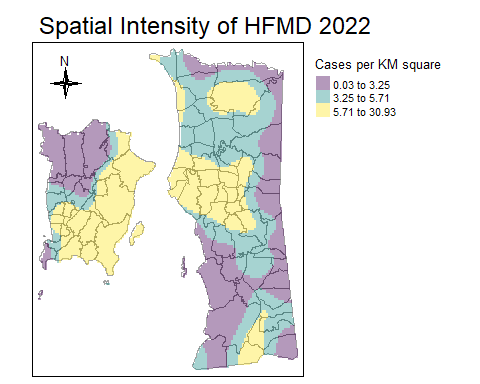
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2020.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(5, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2020",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



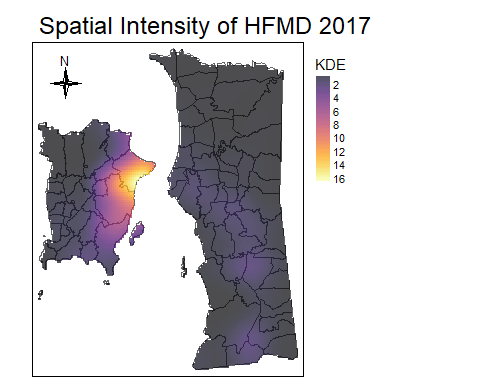
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2021.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(5, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2021",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



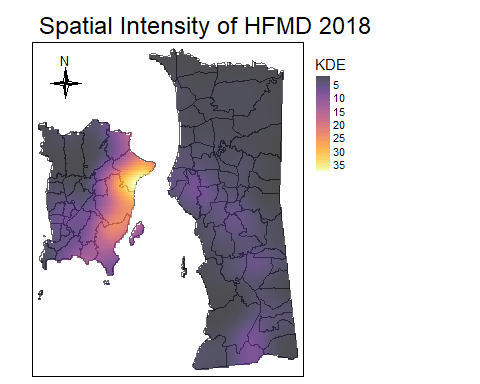
tm\_shape(Penang) +  
 tm\_borders(alpha=.6) +  
 tm\_shape(Y2022.coor.density.raster) +   
 tm\_raster(style = "quantile", n = 3 , palette = viridis(7, direction = 1), alpha = .4, title = "Cases per KM square") + tm\_layout(main.title = "Spatial Intensity of HFMD 2022",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



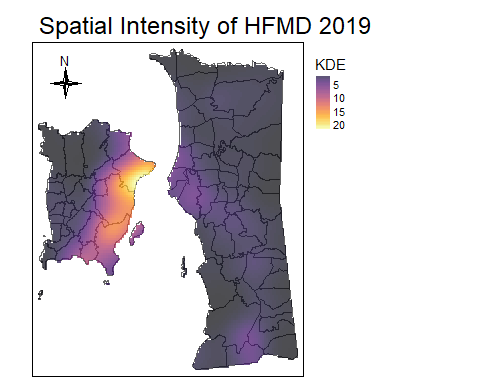
tm\_shape(Penang) +  
 tm\_borders(alpha= 1) +  
 tm\_shape(Y2017.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2017",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



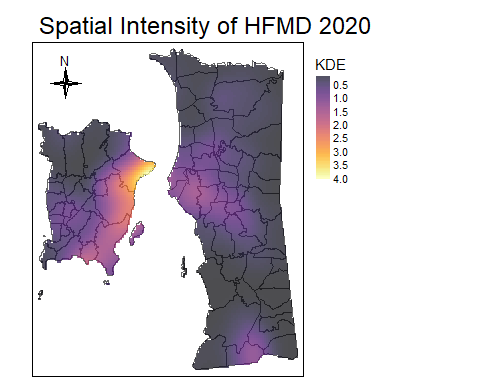
tm\_shape(Penang) +  
 tm\_borders(alpha= 1) +  
 tm\_shape(Y2018.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2018",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



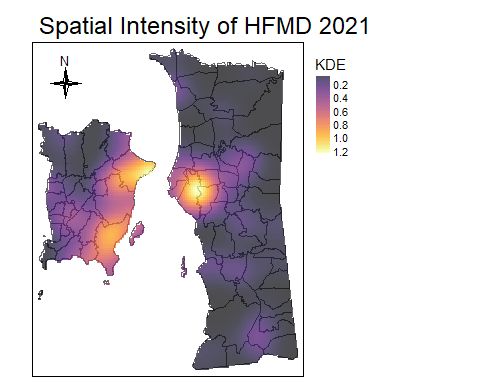
tm\_shape(Penang) +  
 tm\_borders(alpha= 1) +  
 tm\_shape(Y2019.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2019",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



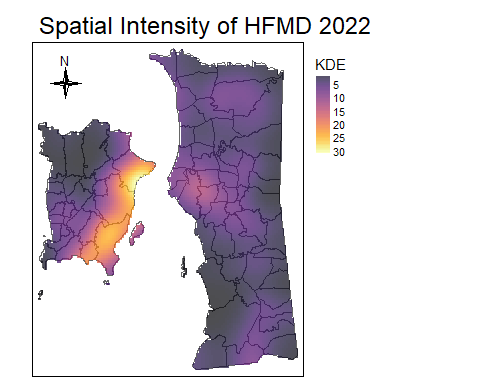
tm\_shape(Penang) +  
 tm\_borders(alpha= 1) +  
 tm\_shape(Y2020.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2020",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



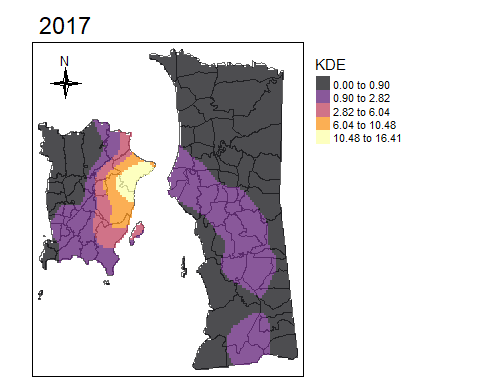
tm\_shape(Penang) +  
 tm\_borders(alpha= 1) +  
 tm\_shape(Y2021.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2021",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



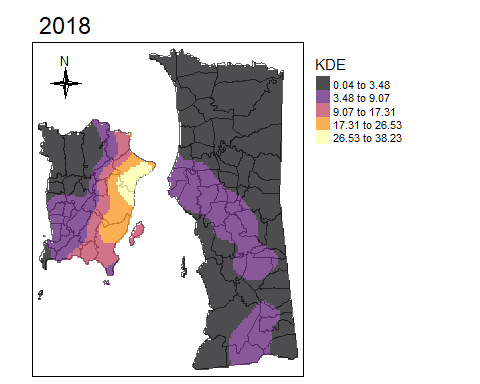
tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2022.coor.density.raster) +   
 tm\_raster(style = "cont", n = 7 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "Spatial Intensity of HFMD 2022",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



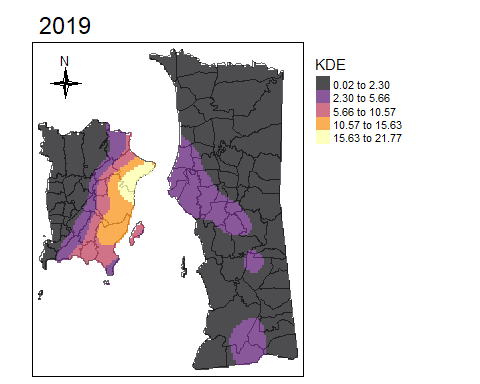
tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2017.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2017",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



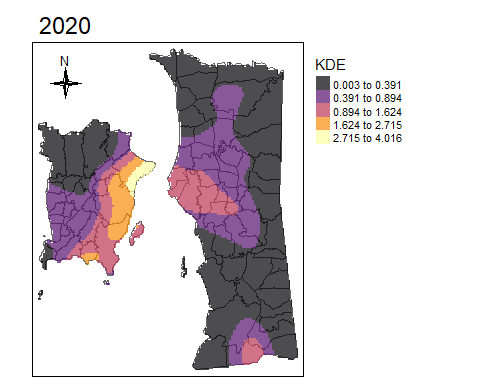
tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2018.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2018",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



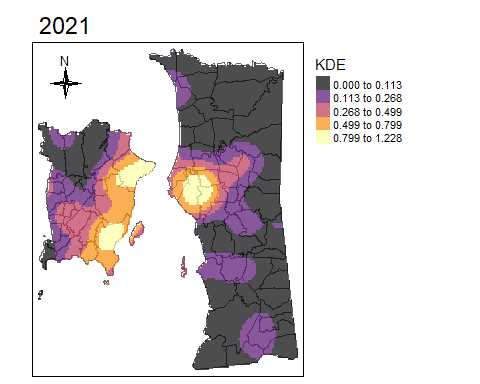
tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2019.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2019",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



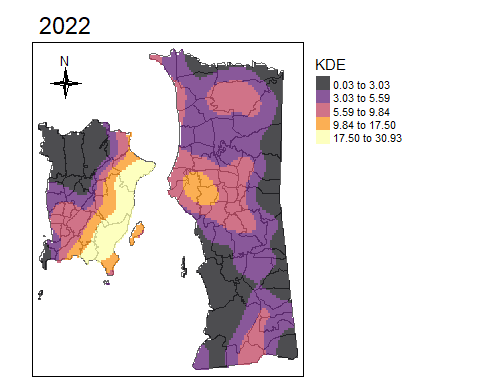
tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2020.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2020",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2021.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2021",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



tm\_shape(Penang) +  
 tm\_borders(alpha=1) +  
 tm\_shape(Y2022.coor.density.raster) +   
 tm\_raster(style = "fisher", n = 5 , palette = "inferno", alpha = .7, title = "KDE") + tm\_layout(main.title = "2022",title.size=1)+  
 tm\_layout(legend.outside = TRUE)+ tm\_compass(type = "4star", size = 2, position = c("left", "top"))



#KDE intensity by Gender ## Select Gender and Coordinate from data

Coor\_Gender <- HFMD\_overall[,c(1,8)]  
Coor\_Gender <- na.omit(Coor\_Gender)

#Specified coordinate for male and female

Male.coor <- subset(Coor\_Gender, GENDER=='Lelaki')   
Female.coor <- subset(Coor\_Gender, GENDER=='Perempuan')

#Load a point feature shapefile into Penang.owin

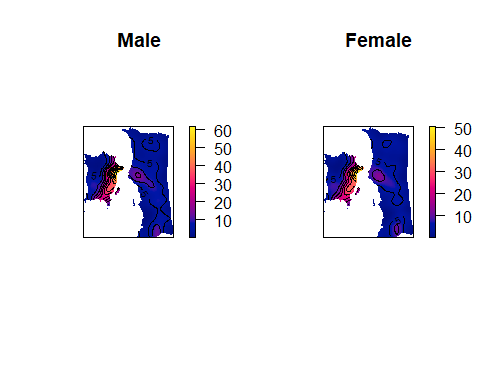
Male.coor.ppp <- as.ppp(Male.coor)  
marks(Male.coor.ppp ) <- NULL  
Male.coor.ppp <- rescale(Male.coor.ppp , 1000,"km")  
Window(Male.coor.ppp ) <- Penang.owin.km  
Female.coor.ppp <- as.ppp(Female.coor)  
marks(Female.coor.ppp ) <- NULL  
Female.coor.ppp <- rescale(Female.coor.ppp , 1000,"km")  
Window(Female.coor.ppp ) <- Penang.owin.km

#Create Density function for gender

Male.coor.density<- density(Male.coor.ppp , sigma=2)   
Female.coor.density <- density(Female.coor.ppp , sigma=2)

#Plot KDE for gender

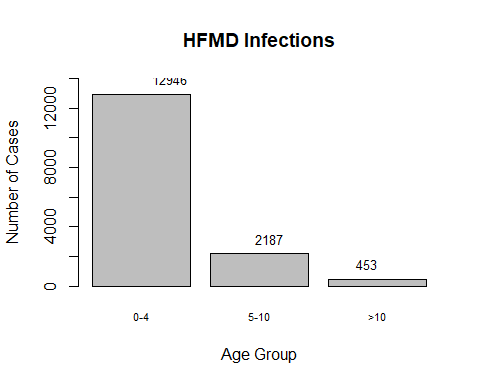
par(mfrow=c(1,2))  
plot(Male.coor.density, main = "Male", las = 1)  
contour(Male.coor.density, add = TRUE)  
plot(Female.coor.density, main = "Female", las = 1)  
contour(Female.coor.density, add = TRUE)

 #KDE intensity by Age Group #Categorise age of the cases

HFMD\_overall ["age\_group"] = cut (HFMD\_overall$AGE, c (0,5,10,Inf),c("0-4","5-10",">10"), include.lowest = TRUE)

#Plot Case vs Age Group

counts <- table(HFMD\_overall$age\_group)  
barplot(counts, main = "HFMD Infections", xlab = "Age Group",  
 ylab = "Number of Cases", cex.axis = 1, cex.lab = 1, cex.names = 0.7, ylim = c(0, 14000))  
text(x = 1:length(counts), y = counts, labels = counts, pos = 3, cex = 0.8)

 #KDE density for each age group

Coor\_Age <- HFMD\_overall[,c(1,13)]  
Coor\_Age <- na.omit(Coor\_Age )

#Specified coordinate for each age group

Coor\_Age\_1 <- subset(Coor\_Age, age\_group =='0-4')   
Coor\_Age\_2 <- subset(Coor\_Age, age\_group =='5-10')   
Coor\_Age\_3 <- subset(Coor\_Age, age\_group =='>10')

#Load a point feature shapefile into Penang.owin

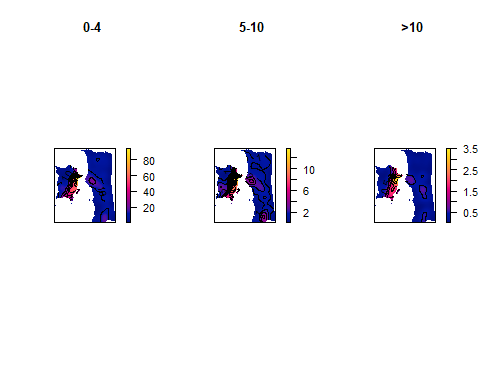
Coor\_Age\_1.ppp <- as.ppp(Coor\_Age\_1)  
marks(Coor\_Age\_1.ppp ) <- NULL  
Coor\_Age\_1.ppp <- rescale(Coor\_Age\_1.ppp , 1000,"km")  
Window(Coor\_Age\_1.ppp ) <- Penang.owin.km  
Coor\_Age\_2.ppp <- as.ppp(Coor\_Age\_2)  
marks(Coor\_Age\_2.ppp ) <- NULL  
Coor\_Age\_2.ppp <- rescale(Coor\_Age\_2.ppp , 1000,"km")  
Window(Coor\_Age\_2.ppp ) <- Penang.owin.km  
Coor\_Age\_3.ppp <- as.ppp(Coor\_Age\_3)  
marks(Coor\_Age\_3.ppp ) <- NULL  
Coor\_Age\_3.ppp <- rescale(Coor\_Age\_3.ppp , 1000,"km")  
Window(Coor\_Age\_3.ppp ) <- Penang.owin.km

#Create Density function for each age group

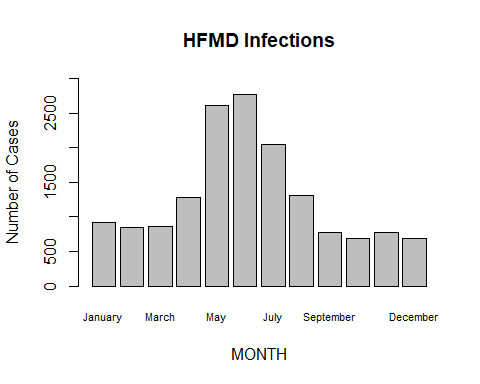
Coor\_Age\_1.density<- density(Coor\_Age\_1.ppp, sigma=2)   
Coor\_Age\_2.density<- density(Coor\_Age\_2.ppp, sigma=2)   
Coor\_Age\_3.density<- density(Coor\_Age\_3.ppp, sigma=2)

#Plot KDE for each age group

par(mfrow=c(1,3))  
plot(Coor\_Age\_1.density, main = "0-4", las = 1)  
contour(Coor\_Age\_1.density, add = TRUE)  
plot(Coor\_Age\_2.density, main = "5-10", las = 1)  
contour(Coor\_Age\_2.density, add = TRUE)  
plot(Coor\_Age\_3.density, main = ">10", las = 1)  
contour(Coor\_Age\_3.density, add = TRUE)

 #Plot Case vs Month

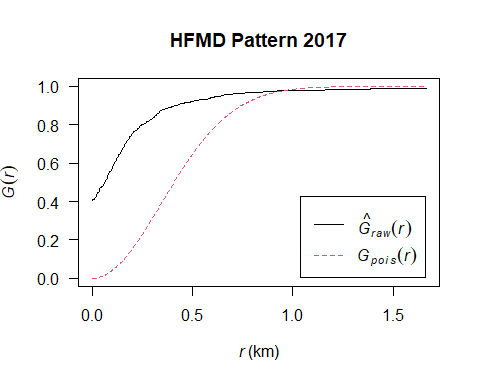
counts <- table(HFMD\_overall$MONTH)  
barplot(counts, main = "HFMD Infections", xlab = "MONTH",  
 ylab = "Number of Cases", cex.axis = 1, cex.lab = 1, cex.names = 0.7, ylim = c(0, 3000))



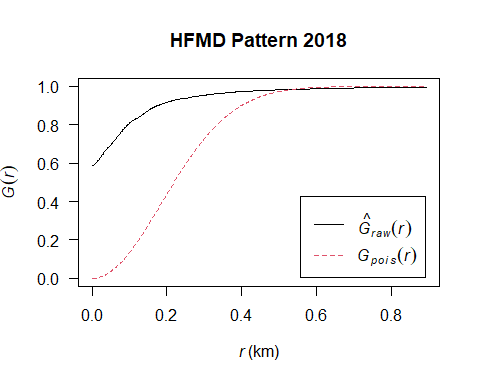
# Test for clustering using Gest Test

# Use split to calculate the G-function   
g\_pattern\_2017 <- Gest(Y2017\_coor.ppp, correction = "none")  
g\_pattern\_2018 <- Gest(Y2018\_coor.ppp, correction = "none")  
g\_pattern\_2019 <- Gest(Y2019\_coor.ppp, correction = "none")  
g\_pattern\_2020 <- Gest(Y2020\_coor.ppp, correction = "none")  
g\_pattern\_2021 <- Gest(Y2021\_coor.ppp, correction = "none")  
g\_pattern\_2022 <- Gest(Y2022\_coor.ppp, correction = "none")

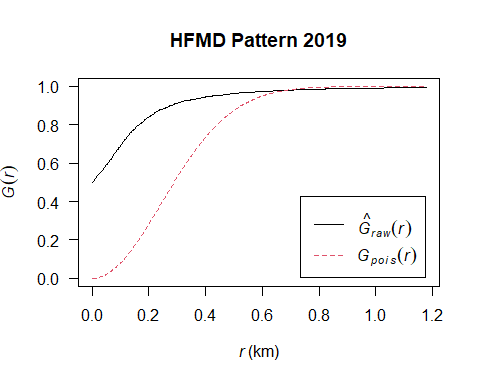
plot(g\_pattern\_2017, main = "HFMD Pattern 2017", las = 1)



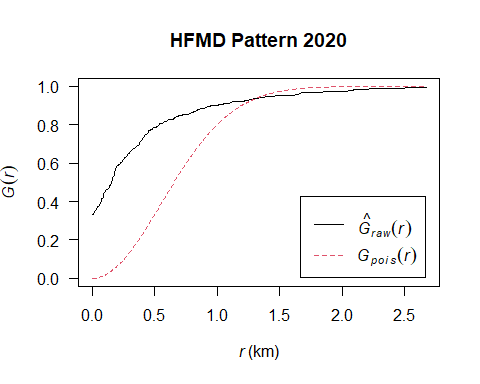
plot(g\_pattern\_2018, main = "HFMD Pattern 2018", las = 1)



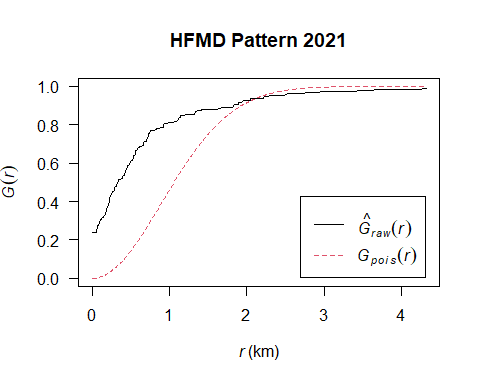
plot(g\_pattern\_2019, main = "HFMD Pattern 2019", las = 1)



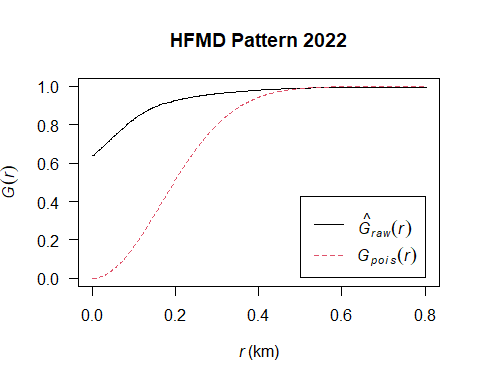
plot(g\_pattern\_2020, main = "HFMD Pattern 2020", las = 1)



plot(g\_pattern\_2021, main = "HFMD Pattern 2021", las = 1)



plot(g\_pattern\_2022, main = "HFMD Pattern 2022", las = 1)



# Generate 99 simulated point patterns under CSR and compute Gest for each  
sim\_gest\_17 <- envelope(Y2017\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

sim\_gest\_18 <- envelope(Y2018\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

sim\_gest\_19 <- envelope(Y2019\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

sim\_gest\_20 <- envelope(Y2020\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

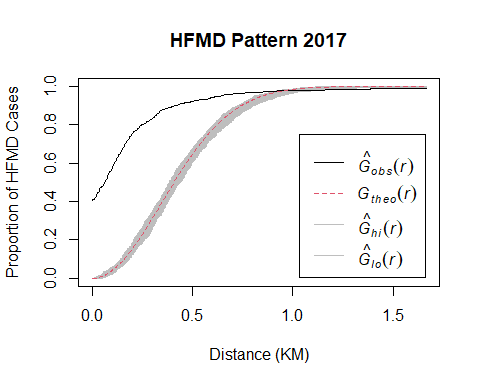
sim\_gest\_21 <- envelope(Y2021\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

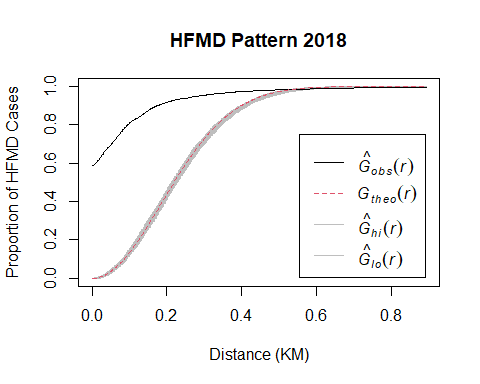
sim\_gest\_22 <- envelope(Y2022\_coor.ppp, Gest, nsim = 99, correction = "none")

## Generating 99 simulations of CSR ...  
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,  
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,  
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99.  
##   
## Done.

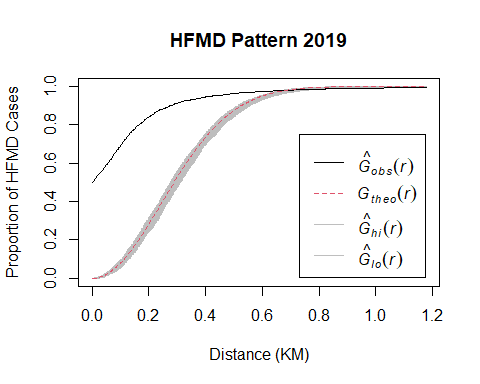
# Plot observed Gest value with envelope  
plot(sim\_gest\_17, main = "HFMD Pattern 2017",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



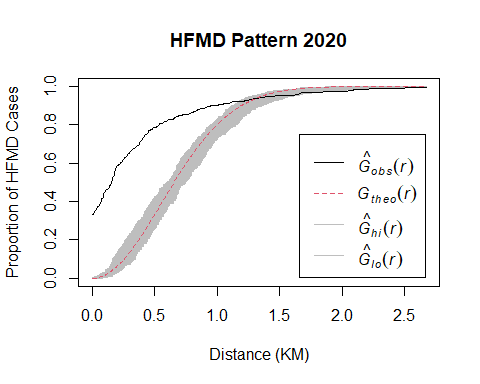
plot(sim\_gest\_18, main = "HFMD Pattern 2018",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



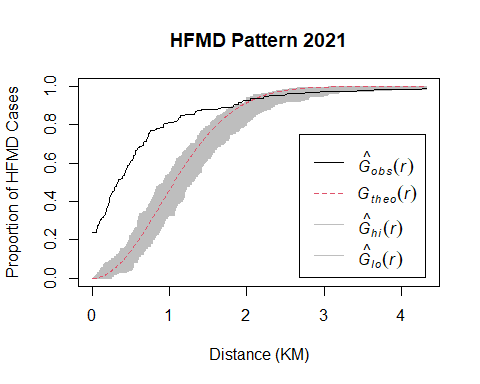
plot(sim\_gest\_19, main = "HFMD Pattern 2019",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



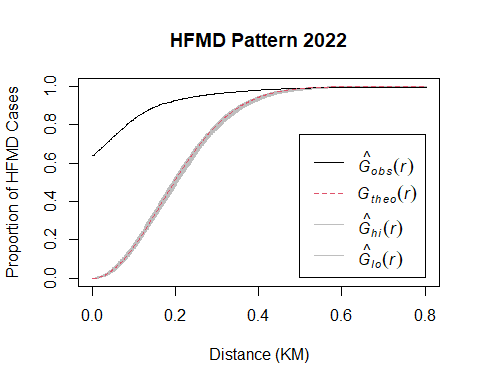
plot(sim\_gest\_20, main = "HFMD Pattern 2020",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



plot(sim\_gest\_21, main = "HFMD Pattern 2021",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



plot(sim\_gest\_22, main = "HFMD Pattern 2022",xlab = "Distance (KM)",  
 ylab = "Proportion of HFMD Cases", cex.axis = 1, cex.lab = 1)



library(gtsummary)

## Warning: package 'gtsummary' was built under R version 4.2.3

##   
## Attaching package: 'gtsummary'

## The following object is masked from 'package:raster':  
##   
## select

library(tidyverse)

Descr\_Overal <- read\_excel( here("Density Based Analysis",  
 "tbl\_data\_HFMD.xlsx")) %>%  
 select(YEAR,AGE,age\_group,GENDER,RACE,DISTRICT)

tbl\_summary(Descr\_Overal,  
 by = YEAR,  
 label = list(AGE~ "Age", age\_group ~ "Age Group"),  
statistic = c(all\_categorical() ~ "{n} ({p}%)",  
 all\_continuous() ~ "{mean} ({sd})"))%>%  
 bold\_labels() %>%   
 italicize\_levels()%>%   
 add\_overall()

| **Characteristic** | **Overall**, N = 15,586 | **2017**, n = 1,378 | **2018**, n = 4,793 | **2019**, n = 2,752 | **2020**, n = 534 | **2021**, n = 205 | **2022**, n = 5,924 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Age** | 3.53 (3.68) | 3.11 (2.51) | 3.42 (2.74) | 3.15 (2.43) | 2.93 (2.56) | 2.24 (1.69) | 4.00 (4.93) |
| **Age Group** |  |  |  |  |  |  |  |
| *>10* | 453 (2.9%) | 24 (1.7%) | 137 (2.9%) | 48 (1.7%) | 10 (1.9%) | 2 (1.0%) | 232 (3.9%) |
| *0-4* | 12,946 (83%) | 1,202 (87%) | 3,930 (82%) | 2,379 (86%) | 464 (87%) | 197 (96%) | 4,774 (81%) |
| *5-10* | 2,187 (14%) | 152 (11%) | 726 (15%) | 325 (12%) | 60 (11%) | 6 (2.9%) | 918 (15%) |
| **GENDER** |  |  |  |  |  |  |  |
| *Female* | 7,093 (46%) | 612 (44%) | 2,184 (46%) | 1,269 (46%) | 243 (46%) | 86 (42%) | 2,699 (46%) |
| *Male* | 8,493 (54%) | 766 (56%) | 2,609 (54%) | 1,483 (54%) | 291 (54%) | 119 (58%) | 3,225 (54%) |
| **RACE** |  |  |  |  |  |  |  |
| *Cina* | 4,582 (29%) | 726 (53%) | 1,710 (36%) | 1,223 (44%) | 134 (25%) | 17 (8.3%) | 772 (13%) |
| *India* | 664 (4.3%) | 96 (7.0%) | 228 (4.8%) | 134 (4.9%) | 22 (4.1%) | 2 (1.0%) | 182 (3.1%) |
| *Melayu* | 10,160 (65%) | 542 (39%) | 2,768 (58%) | 1,365 (50%) | 375 (70%) | 186 (91%) | 4,924 (83%) |
| *Non-Malaysian* | 105 (0.7%) | 9 (0.7%) | 54 (1.1%) | 11 (0.4%) | 1 (0.2%) | 0 (0%) | 30 (0.5%) |
| *Others* | 75 (0.5%) | 5 (0.4%) | 33 (0.7%) | 19 (0.7%) | 2 (0.4%) | 0 (0%) | 16 (0.3%) |
| **DISTRICT** |  |  |  |  |  |  |  |
| *Barat Daya* | 3,389 (22%) | 177 (13%) | 1,074 (22%) | 621 (23%) | 115 (22%) | 63 (31%) | 1,339 (23%) |
| *S.Perai Selatan* | 2,198 (14%) | 219 (16%) | 780 (16%) | 345 (13%) | 49 (9.2%) | 21 (10%) | 784 (13%) |
| *S.Perai Tengah* | 2,737 (18%) | 214 (16%) | 710 (15%) | 374 (14%) | 123 (23%) | 63 (31%) | 1,253 (21%) |
| *S.Perai Utara* | 2,042 (13%) | 58 (4.2%) | 353 (7.4%) | 368 (13%) | 84 (16%) | 14 (6.8%) | 1,165 (20%) |
| *Timur Laut* | 5,220 (33%) | 710 (52%) | 1,876 (39%) | 1,044 (38%) | 163 (31%) | 44 (21%) | 1,383 (23%) |

#calculate NNI  
library(spatialEco)

## Warning: package 'spatialEco' was built under R version 4.2.3

##   
## Attaching package: 'spatialEco'

## The following object is masked from 'package:raster':  
##   
## shift

## The following objects are masked from 'package:spatstat.geom':  
##   
## is.empty, quadrats, shift

## The following object is masked from 'package:spatstat.data':  
##   
## ants

## The following object is masked from 'package:dplyr':  
##   
## combine

NNI\_17 <- nni(Y2017\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

NNI\_18 <- nni(Y2018\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

NNI\_19 <- nni(Y2019\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

NNI\_20 <- nni(Y2020\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

NNI\_21 <- nni(Y2021\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

NNI\_22 <- nni(Y2022\_coor, win = c ("hull", "extent"))

## Warning: data contain duplicated points

combined\_NNI <- bind\_rows(NNI\_17,NNI\_18,NNI\_19,NNI\_20,NNI\_21,NNI\_22)  
print(combined\_NNI)

## # A tibble: 6 × 5  
## NNI z.score p expected.mean.distance observed.mean.distance  
## <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 0.325 -48.0 0 504. 163.   
## 2 0.227 -102. 0 280. 63.5  
## 3 0.270 -73.3 0 368. 99.2  
## 4 0.432 -25.1 2.21e-139 794. 343.   
## 5 0.518 -13.2 9.25e- 40 1225. 635.   
## 6 0.201 -118. 0 252. 50.6