

Spatial Autocorrelation and Areal Data

HES 505 Fall 2023: Session 21

Matt Williamson

Objectives

By the end of today you should be able to:

- Use the **spdep** package to identify the neighbors of a given polygon based on proximity, distance, and minimum number
- Understand the underlying mechanics of Moran's I and calculate it for various neighbors
- Distinguish between global and local measures of spatial autocorrelation
- Visualize neighbors and clusters

Revisiting Spatial Autocorrelation

Spatial Autocorrelation

- Attributes (features) are often non-randomly distributed
- Especially true with aggregated data
- Interest is in the relationship between proximity and the feature
- Difference from kriging and semivariance

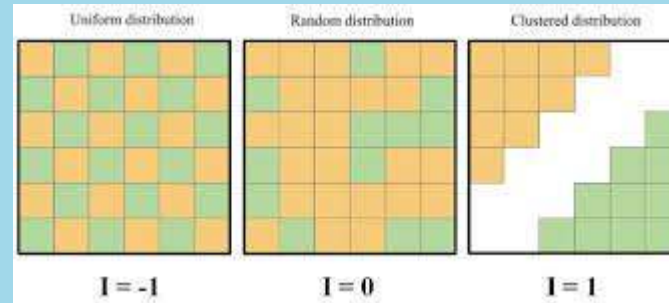


From Manuel Gimond

Moran's I

- Moran's I

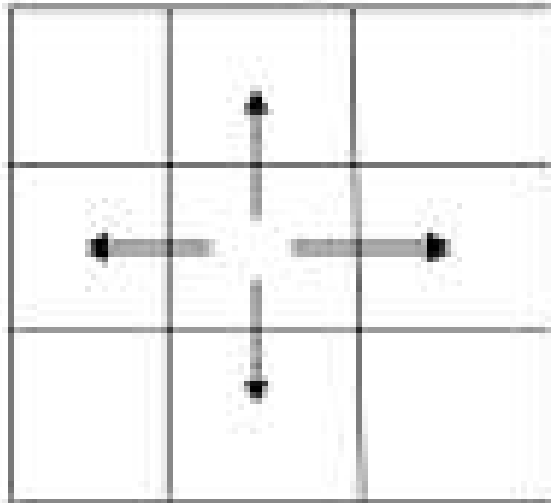
$$I(d) = \frac{\sum_i \sum_{j \neq i}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{S^2 \sum_i \sum_{j \neq i}^n w_{ij}}$$



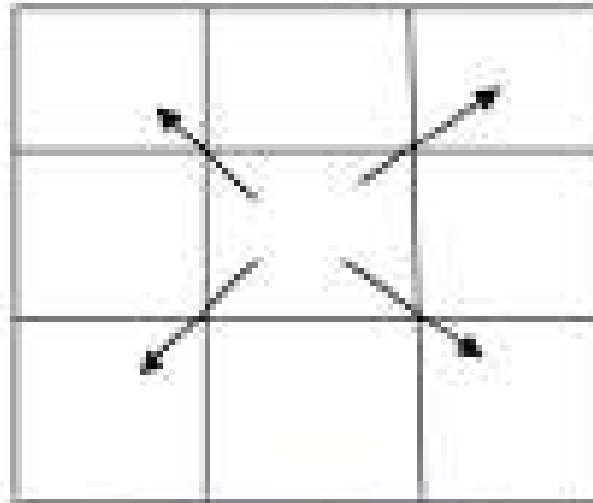
Finding Neighbors

- How do we define $I(d)$ for areal data?
- What about w_{ij} ?
- We can use **spdep** for that!!

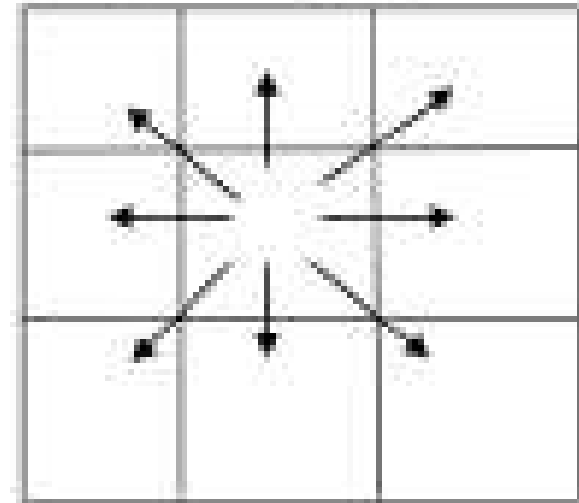
A: Rook's Contiguity



B: Bishop's contiguity

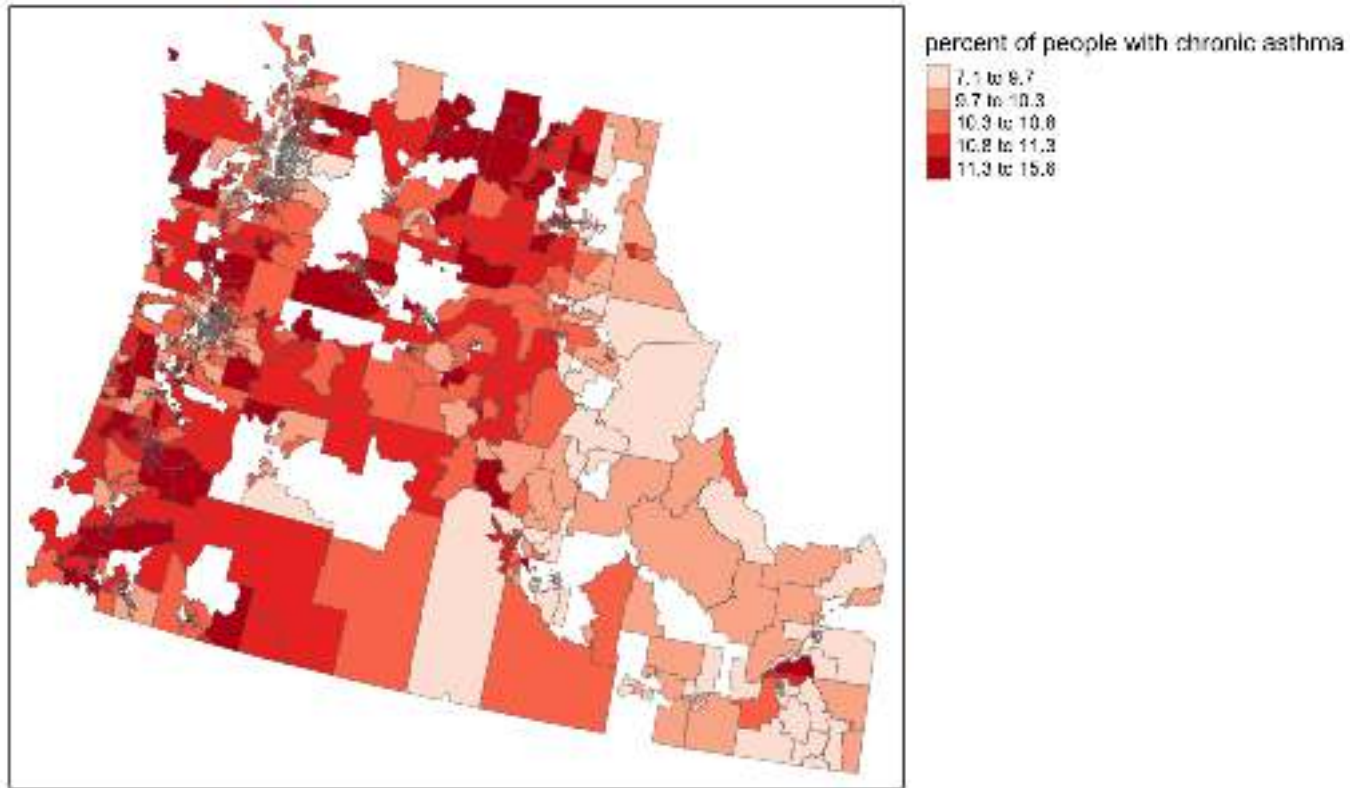


C: Queen's contiguity



Using **spdep**

```
1 cdc <- read_sf("data/opt/data/2023/vectorexample/cdc_nw.shp") %>%  
2   select(stateabbr, countname, countyfips, casthma_cr)
```

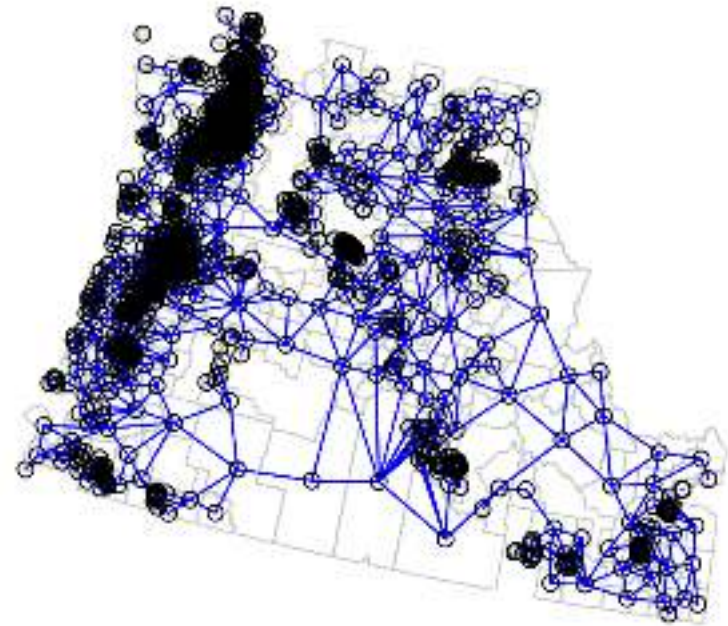
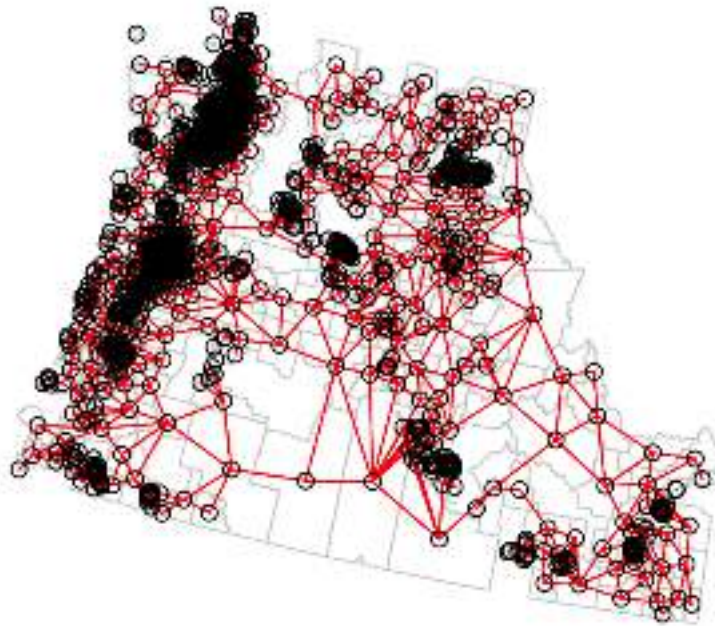


Finding Neighbors

- Queen, rook, (and bishop) cases impose neighbors by contiguity
- Weights calculated as a $1/\text{num. of neighbors}$

```
1 nb.qn <- poly2nb(cdc, queen=TRUE)
2 nb.rk <- poly2nb(cdc, queen=FALSE)
```

Finding Neighbors



Getting Weights

```
1 lw.qn <- nb2listw(nb.qn, style="W", zero.p  
2 lw.qn$weights[1:5]
```

```
[[1]]
```

```
[1] 0.5 0.5
```

```
[[2]]
```

```
[1] 0.25 0.25 0.25 0.25
```

```
[[3]]
```

```
[1] 0.2 0.2 0.2 0.2 0.2
```

```
[[4]]
```

```
[1] 0.3333333 0.3333333 0.3333333
```

```
[[5]]
```

```
[1] 1
```

```
1 asthma.lag <- lag.listw(lw.qn, cdc$casthma
```

```
asthma.lag
```

```
[1,] "Camas" "9.9"
```

```
"10.3"
```

```
[2,] "Kootenai" "10.4"
```

```
"9.575"
```

```
[3,] "Kootenai" "10"
```

```
"9.88"
```

```
[4,] "Kootenai" "9.5"
```

```
"10.26666666666667"
```

```
[5,] "Twin Falls" "10.2"
```

```
"9.5"
```

```
[6,] "Twin Falls" "10.4"
```

```
"9.9"
```

Fit a model

- Moran's I coefficient is the slope of the regression of the *lagged* asthma percentage vs. the asthma percentage in the tract
- More generally it is the slope of the lagged average to the measurement

```
1 M <- lm(asthma.lag ~ cdc$casthma_cr)
```

```
cdc$casthma_cr  
0.6467989
```

Comparing observed to expected

- We can generate the expected distribution of Moran's I coefficients under a Null hypothesis of no spatial autocorrelation
- Using permutation and a loop to generate simulations of Moran's I

```
1  n <- 400L    # Define the number of simulations
2  I.r <- vector(length=n) # Create an empty vector
3
4  for (i in 1:n){
5    # Randomly shuffle income values
6    x <- sample(cdc$casthma_cr, replace=FALSE)
7    # Compute new set of lagged values
8    x.lag <- lag.listw(lw.qn, x)
9    # Compute the regression slope and store its value
10   M.r    <- lm(x.lag ~ x)
```

```
11     I.r[i] <- coef(M.r)[2]  
12 }
```

