Spatial Autocorrelation and Areal Data

HES 505 Fall 2023: Session 21

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Objectives

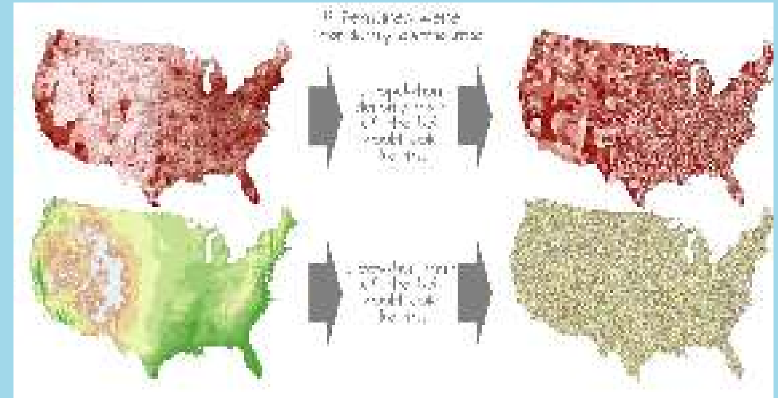
By the end of today you should be able to:

- 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

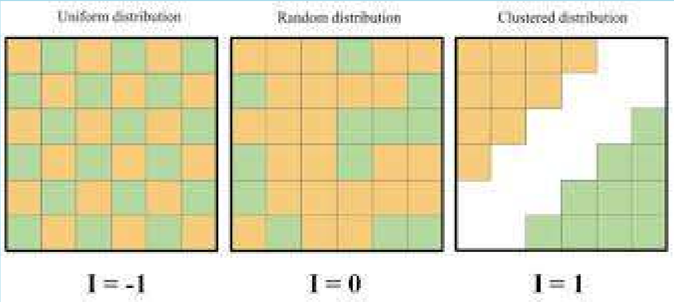


From Manuel Gimond

Moran’s I

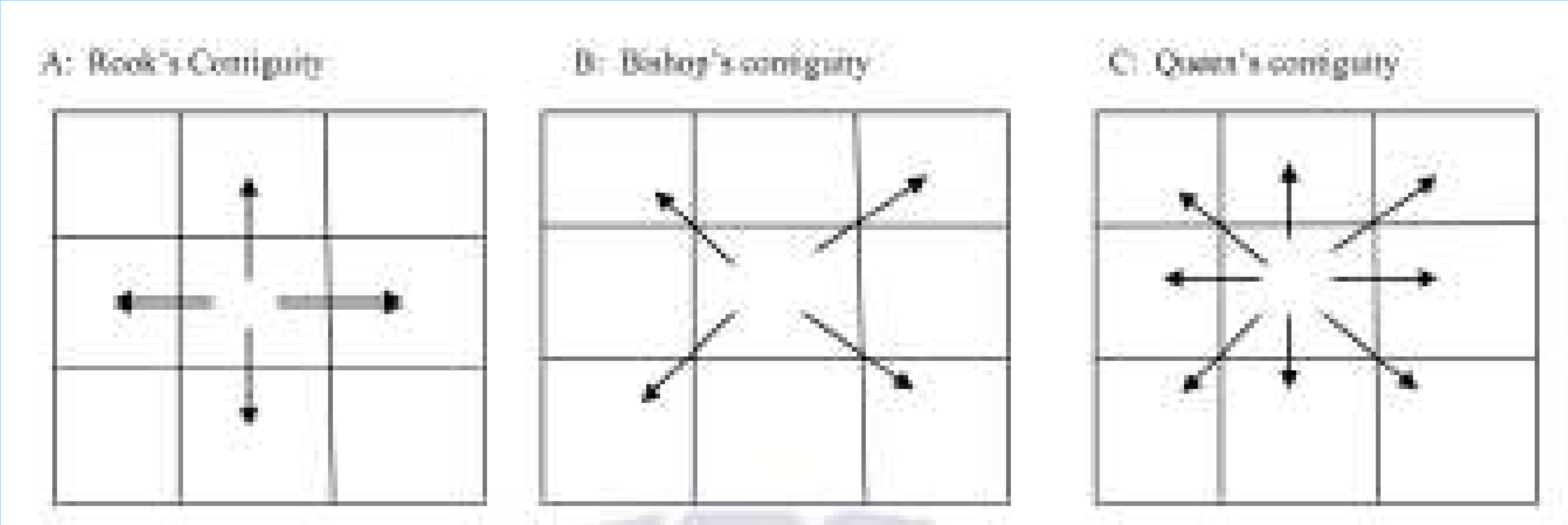
- Moran’s I

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



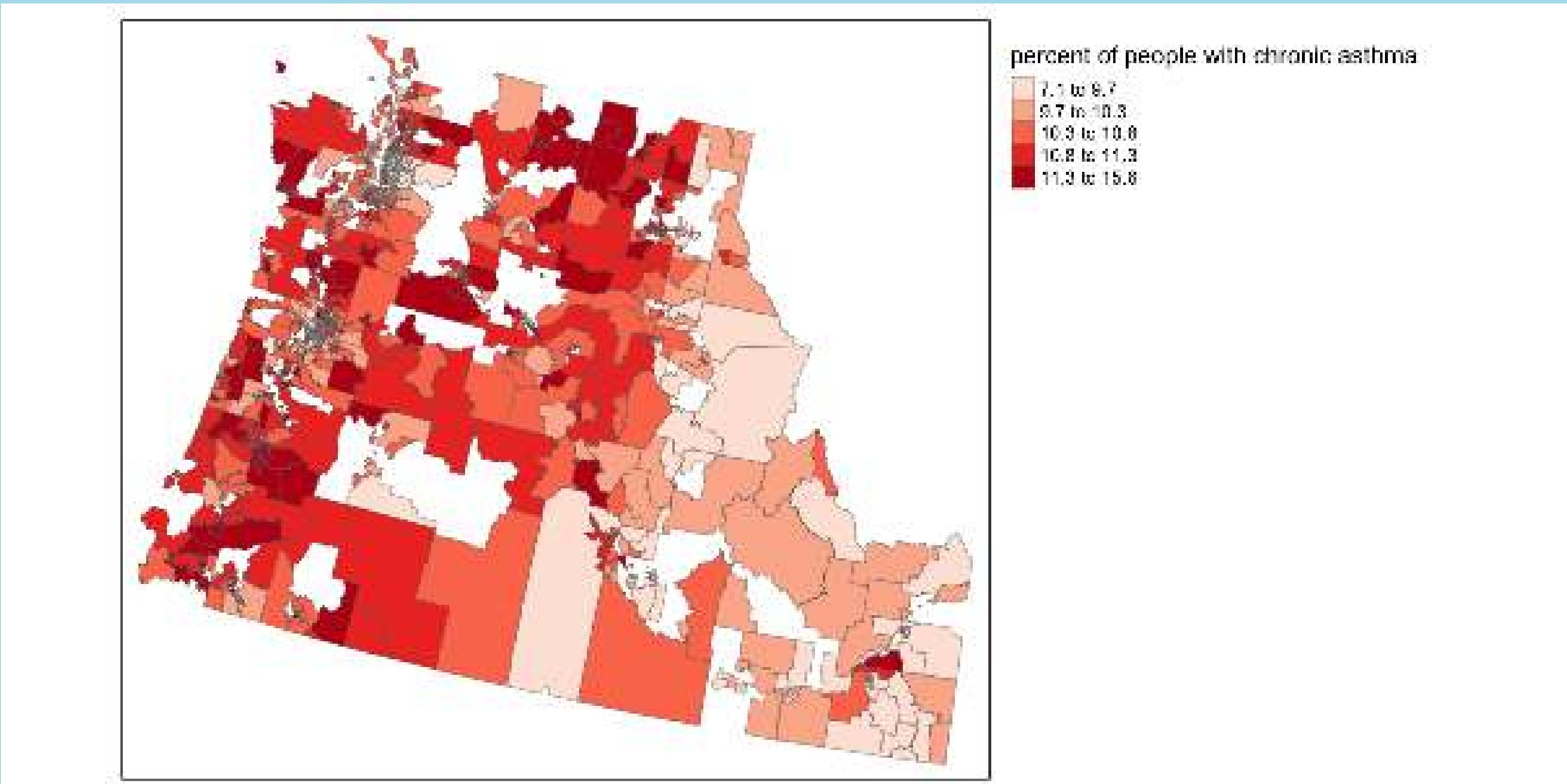
Finding Neighbors

- 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

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

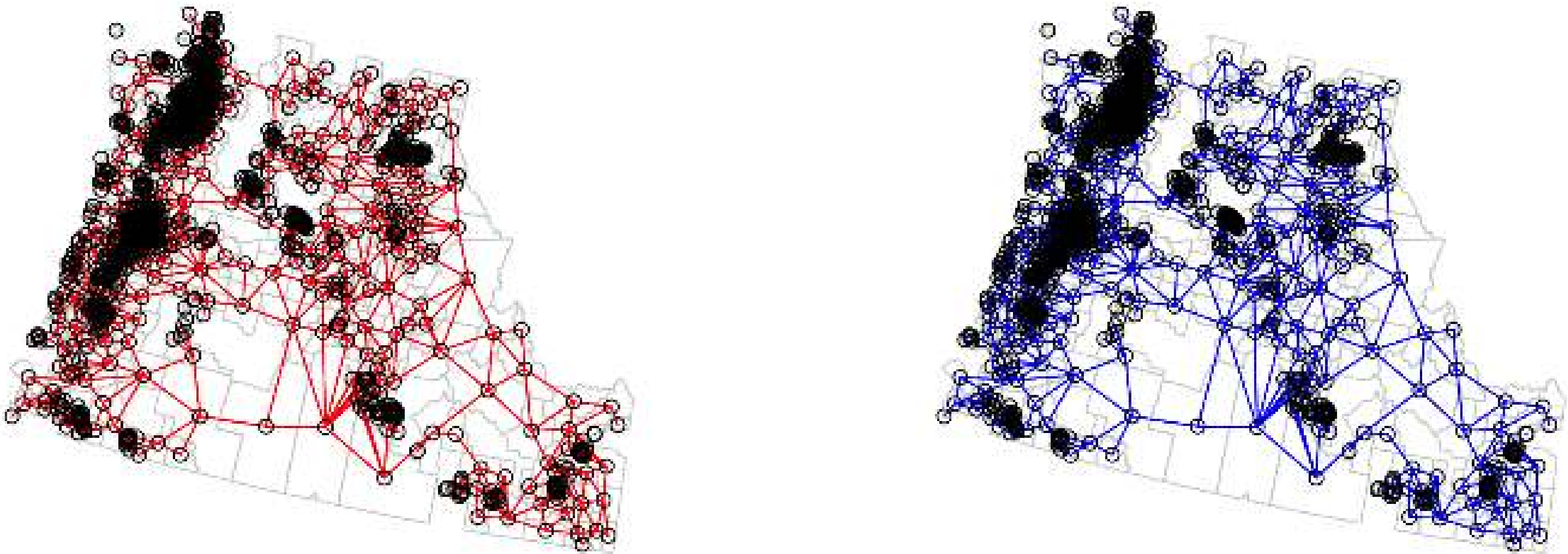


Finding Neighbors

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

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

Finding Neighbors



Getting Weights

```r
lw.qn <- nb2listw(nb.qn, style="W", zero.p
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
```

```r
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"
"10.2666666666667"
[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

```r
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

```
n <- 400L   # Define the number of simulations
I.r <- vector(length=n)  # Create an empty vector

for (i in 1:n){
  # Randomly shuffle income values
  x <- sample(cdc$casthma_cr, replace=FALSE)
  # Compute new set of lagged values
  x.lag <- lag.listw(lw.qn, x)
  # Compute the regression slope and store its value
  M.r    <- lm(x.lag ~ x)
```

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