Coastal Analysis

TLDR: To replicate tables in slides, run tab_model commands at the bottom (that is, after running all the models)

Read in data

```
library(readxl)
library(lme4)
```

```
## Loading required package: Matrix
```

```
library(sjPlot)
```

```
## Install package "strengejacke" from GitHub (`devtools::install_github("strengejacke/strengejacke")`)
```

```
library(sjmisc)
library(sjlabelled)

# Read in dataset with coastal coding. Read in summary sheet (sheet
# 13)
coastal <- read_excel("FIPS-based datasets_05232021.xlsx", sheet = 13)
```

```
## New names:
## * `` -> ...12
## * `` -> ...22
## * `` -> ...25
## * `` -> ...39
```

```
# summary(coastal)

# Read in PM25 and humidity data from our 2020 study, created with:
# confounding = data.frame(fips =
# aggregate_pm_census_cdc_test_beds$fips, q_popdensity =
# aggregate_pm_census_cdc_test_beds$q_popdensity, poverty.old =
# aggregate_pm_census_cdc_test_beds$poverty, median_house_value =
# aggregate_pm_census_cdc_test_beds$median_house_value,
# median_household_income =
# aggregate_pm_census_cdc_test_beds$median_household_income,
# owner_occupied = aggregate_pm_census_cdc_test_beds$owner_occupied,
# blk_pct = aggregate_pm_census_cdc_test_beds$blk_pct, hispanic_pct =
# aggregate_pm_census_cdc_test_beds$hispanic_pct, white_pct =
# aggregate_pm_census_cdc_test_beds$white_pct, native_pct =
```

```
# aggregate_pm_census_cdc_test_beds$native_pct, asian_pct =
# aggregate_pm_census_cdc_test_beds$asian_pct, no_grad =
# aggregate_pm_census_cdc_test_beds$no_grad, date_since_social =
# aggregate_pm_census_cdc_test_beds$date_since_social, date_since =
# aggregate_pm_census_cdc_test_beds$date_since, beds =
# aggregate_pm_census_cdc_test_beds$beds, population.old =
# aggregate_pm_census_cdc_test_beds$population, obese =
# aggregate_pm_census_cdc_test_beds$obese, smoke =
# aggregate_pm_census_cdc_test_beds$smoke, mean_summer_temp =
# aggregate_pm_census_cdc_test_beds$mean_summer_temp,
# mean_winter_temp =
# aggregate_pm_census_cdc_test_beds$mean_winter_temp, mean_pm25 =
# aggregate_pm_census_cdc_test_beds$mean_pm25, mean_summer_rm =
# aggregate_pm_census_cdc_test_beds$mean_summer_rm, mean_winter_rm =
# aggregate_pm_census_cdc_test_beds$mean_winter_rm) save(confounding,
# file = 'confounding.Rda')
load("confounding.Rda")
```

Create smaller datasets from previous datasets, dataclean, merge region dataset with summary dataset, finally merge with PM25 dataset.

```
coastal.new = data.frame(coastal$`FIPS as Text`, coastal$state, coastal$cases,
    coastal$deaths, coastal$`Country REGION`, coastal$`Coastal Distance`,
    coastal$`Population 2019 Estimate`, coastal$`Population Density`, coastal$`All Ages in Poverty (%)`
    coastal$`Under 18s in Poverty`, coastal$`Median Income`, coastal$`percent adult obesity`,
    coastal$`diff/total`, coastal$`Politcal alignment 2020 election`, coastal$`median age 2019`,
    coastal$Humid)
colnames(coastal.new) = c("fips", "state", "cases", "deaths", "region",
    "coastal.distance", "population2019", "popdensity", "poverty", "under18poverty",
    "median_income", "pct_obesity", "voter_margin_2020", "party", "median_age",
    "humidity")

# change NAs in coastal.distance to level 4, and save as factor with
# reference level 4.
coastal.new$coastal.distance[is.na(coastal.new$coastal.distance)] <- 4
coastal.new$coastal.distance = as.factor(coastal.new$coastal.distance)
coastal.new <- within(coastal.new, coastal.distance <- relevel(coastal.distance,
    ref = 4))

# change NAs in coastal region to Inland, and save as factor with
# reference level Inland
coastal.new$region[is.na(coastal.new$region)] <- "Inland"
coastal.new$region[coastal.new$region == "0"] <- "Inland"
coastal.new$region = tolower(coastal.new$region)
coastal.new$region = as.factor(coastal.new$region)
coastal.new <- within(coastal.new, region <- relevel(region, ref = "inland"))

# Merge with confounding dataset
coastal.new = merge(coastal.new, confounding, by = "fips")
names(coastal.new)[names(coastal.new) == "poverty.x"] <- "poverty"
summary(coastal.new)
```

```
##      fips              state               cases             deaths
##  Length:3100        Length:3100        Min.   :      1   Min.   :    0.0
##  Class :character   Class :character   1st Qu.:   1024   1st Qu.:   18.0
##  Mode  :character   Mode  :character   Median :   2445   Median :   47.0
##                                        Mean   :   9384   Mean   :  165.4
##                                        3rd Qu.:   6124   3rd Qu.:  109.0
##                                        Max.   :1219237   Max.   :23101.0
##
##             region     coastal.distance population2019       popdensity
##  inland        :2426   4:2426           Min.   :     169   Min.   :    0.10
##  atlantic      : 233   1: 300           1st Qu.:   11093   1st Qu.:   17.60
##  gulf of mexico: 129   2: 202           Median :   25884   Median :   45.55
##  pacific       :  87   3: 172           Mean   :  102342   Mean   :  208.15
##  michigan      :  86                    3rd Qu.:   67644   3rd Qu.:  114.12
##  erie          :  45                    Max.   :10039107   Max.   :17179.10
##  (Other)       :  94
##     poverty       under18poverty   median_income     pct_obesity
##  Min.   :0.0270   Min.   :0.0240   Min.   : 24732   Min.   :13.6
##  1st Qu.:0.1050   1st Qu.:0.1370   1st Qu.: 46177   1st Qu.:29.4
##  Median :0.1340   Median :0.1870   Median : 53216   Median :32.4
##  Mean   :0.1448   Mean   :0.2001   Mean   : 55538   Mean   :32.1
##  3rd Qu.:0.1750   3rd Qu.:0.2500   3rd Qu.: 61736   3rd Qu.:35.1
##  Max.   :0.4770   Max.   :0.6340   Max.   :151806   Max.   :49.5
##
##  voter_margin_2020    party             median_age      humidity
##  Min.   :-0.8675   Length:3100        Min.   :22.30   Length:3100
##  1st Qu.: 0.1362   Class :character   1st Qu.:38.20   Class :character
##  Median : 0.3849   Mode  :character   Median :41.40   Mode  :character
##  Mean   : 0.3189                      Mean   :41.48
##  3rd Qu.: 0.5663                      3rd Qu.:44.52
##  Max.   : 0.9309                      Max.   :67.40
##
##   q_popdensity   poverty.y      median_house_value median_household_income
##  Min.   :1     Min.   :0.0181   Min.   : 19800     Min.   : 18972
##  1st Qu.:1     1st Qu.:0.1178   1st Qu.: 88075     1st Qu.: 39650
##  Median :1     Median :0.1568   Median :114150     Median : 46212
##  Mean   :1     Mean   :0.1644   Mean   :135060     Mean   : 47760
##  3rd Qu.:1     3rd Qu.:0.1992   3rd Qu.:157525     3rd Qu.: 53508
##  Max.   :1     Max.   :0.5395   Max.   :966600     Max.   :125672
##
##  owner_occupied      blk_pct          hispanic_pct     date_since_social
##  Min.   :0.2632   Min.   :0.000000   Min.   :0.00000   Min.   :  0.0
##  1st Qu.:0.6750   1st Qu.:0.006274   1st Qu.:0.01932   1st Qu.:  0.0
##  Median :0.7257   Median :0.022637   Median :0.03800   Median :434.0
##  Mean   :0.7134   Mean   :0.090870   Mean   :0.08949   Mean   :310.7
##  3rd Qu.:0.7669   3rd Qu.:0.103510   3rd Qu.:0.09049   3rd Qu.:440.0
##  Max.   :0.9309   Max.   :0.861849   Max.   :0.98959   Max.   :446.0
##
##    date_since         beds          population.old         obese
##  Min.   :  0.0   Min.   :    0.00   Min.   :      76   Min.   :0.1240
##  1st Qu.:157.0   1st Qu.:   20.75   1st Qu.:   11128   1st Qu.:0.2930
##  Median :166.0   Median :   50.00   Median :   25824   Median :0.3310
##  Mean   :156.8   Mean   :  329.19   Mean   :   99194   Mean   :0.3288
##  3rd Qu.:170.0   3rd Qu.:  193.25   3rd Qu.:   67356   3rd Qu.:0.3650
```

```
##  Max.   :170.0   Max.   :30147.00   Max.   :10057155   Max.   :0.5770
##
##      smoke         mean_summer_temp mean_winter_temp   mean_pm25
##  Min.   :0.05909   Min.   :290.5    Min.   :264.7    Min.   : 1.959
##  1st Qu.:0.14941   1st Qu.:300.8    1st Qu.:275.1    1st Qu.: 6.152
##  Median :0.16967   Median :303.3    Median :280.2    Median : 8.360
##  Mean   :0.17459   Mean   :303.1    Mean   :280.4    Mean   : 7.853
##  3rd Qu.:0.19719   3rd Qu.:305.8    3rd Qu.:285.5    3rd Qu.: 9.537
##  Max.   :0.41491   Max.   :313.9    Max.   :298.3    Max.   :12.729
##
##  mean_summer_rm  mean_winter_rm    white_pct         native_pct
##  Min.   :31.64   Min.   :58.16   Min.   :0.04641   Min.   :0.000000
##  1st Qu.:88.09   1st Qu.:85.11   1st Qu.:0.77715   1st Qu.:0.001582
##  Median :91.33   Median :88.03   Median :0.90163   Median :0.003399
##  Mean   :89.02   Mean   :87.50   Mean   :0.83818   Mean   :0.016467
##  3rd Qu.:94.82   3rd Qu.:90.75   3rd Qu.:0.95471   3rd Qu.:0.007701
##  Max.   :99.78   Max.   :97.67   Max.   :1.00000   Max.   :0.930379
##
##    asian_pct           no_grad
##  Min.   :0.000000   Min.   :0.05598
##  1st Qu.:0.002541   1st Qu.:0.16722
##  Median :0.005605   Median :0.20287
##  Mean   :0.011937   Mean   :0.21454
##  3rd Qu.:0.011992   3rd Qu.:0.25323
##  Max.   :0.343781   Max.   :0.54537
##
```

PRELIMINARY ANALYSIS on only coastal counties BEING EDITED

Create indicator for being a coast (degree 1)

```
# Indicator Coastal or NonCoastal
coastal.new$indicatorcoast = ifelse(coastal.new$coastal.distance == "1",
    "Coastal", "NonCoastal")

# Model cases
model.indicator.cases = glmer(cases ~ (1 | state) + factor(indicatorcoast) +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm,
    family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.00391679 (tol = 0.002, component 1)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?;Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
summary(model.indicator.cases)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula:
## cases ~ (1 | state) + factor(indicatorcoast) + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##       AIC       BIC    logLik  deviance  df.resid
##  935401.9  935480.4 -467687.9  935375.9      3087
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -103.66   -6.79   -0.47    6.51  368.23
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.06689  0.2586
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     -8.517e-01  3.718e-02  -22.91   <2e-16 ***
## factor(indicatorcoast)NonCoastal -4.480e-02  5.581e-04  -80.29   <2e-16 ***
## scale(popdensity)                -7.730e-03  1.195e-04  -64.66   <2e-16 ***
```

```
## scale(poverty)                    3.676e-02  6.385e-04   57.58   <2e-16 ***
## scale(log(median_income))        -2.602e-02  5.495e-04  -47.35   <2e-16 ***
## scale(pct_obesity)               -1.429e-02  3.386e-04  -42.20   <2e-16 ***
## scale(voter_margin_2020)          8.812e-02  4.080e-04  216.00   <2e-16 ***
## scale(median_age)                -8.426e-02  3.323e-04 -253.51   <2e-16 ***
## factor(party)Republican          -1.588e-02  7.190e-04  -22.08   <2e-16 ***
## mean_pm25                         2.621e-02  1.997e-04  131.22   <2e-16 ***
## mean_summer_rm                   -5.778e-03  5.033e-05 -114.80   <2e-16 ***
## mean_winter_rm                   -1.388e-02  6.383e-05 -217.52   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) fc()NC scl(pp) scl(pv) s((_)) scl(p_) s(__20 scl(m_) fct()R
## fctr(ndc)NC -0.023
## scl(ppdnst)  0.002  0.210
## scal(pvrty)  0.010  0.002 -0.164
## scl(lg(m_))  0.013 -0.015 -0.078   0.869
## scl(pct_bs)  0.013 -0.056  0.123   0.062   0.323
## scl(__2020)  0.012 -0.106  0.244   0.179   0.166 -0.150
## scal(mdn_g)  0.011  0.163 -0.022   0.304   0.256  0.120  -0.172
## fctr(prty)R -0.015  0.012 -0.128   0.005  -0.026 -0.074  -0.670 -0.071
## mean_pm25   -0.047 -0.014 -0.389   0.014  -0.057 -0.109   0.049  0.073   0.089
## men_smmr_rm  0.000  0.256  0.011  -0.070  -0.103  0.108  -0.078 -0.080   0.003
## men_wntr_rm -0.067 -0.129  0.079  -0.011   0.008 -0.129   0.065 -0.021  -0.041
##             mn_p25 mn_sm_
## fctr(ndc)NC
## scl(ppdnst)
## scal(pvrty)
## scl(lg(m_))
## scl(pct_bs)
## scl(__2020)
## scal(mdn_g)
## fctr(prty)R
## mean_pm25
## men_smmr_rm -0.208
## men_wntr_rm  0.202 -0.746
## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00391679 (tol = 0.002, component 1)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
## Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
# Model deaths
model.indicator.deaths = glmer(deaths ~ (1 | state) + factor(indicatorcoast) +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm,
    family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.indicator.deaths)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula:
## deaths ~ (1 | state) + factor(indicatorcoast) + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  58353.5  58432.0 -29163.7  58327.5     3087
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -23.417  -1.934  -0.226   1.859  32.236
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1305   0.3613
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     -4.6056394  0.0608561 -75.681  < 2e-16 ***
## factor(indicatorcoast)NonCoastal -0.0519986  0.0041067 -12.662  < 2e-16 ***
## scale(popdensity)                -0.0118740  0.0008332 -14.251  < 2e-16 ***
## scale(poverty)                    0.1701441  0.0045947  37.031  < 2e-16 ***
## scale(log(median_income))        -0.0769957  0.0040953 -18.801  < 2e-16 ***
## scale(pct_obesity)                0.0071449  0.0025584   2.793 0.005227 **
## scale(voter_margin_2020)          0.0878212  0.0030514  28.781  < 2e-16 ***
## scale(median_age)                 0.1030206  0.0024419  42.188  < 2e-16 ***
## factor(party)Republican          -0.0203187  0.0054608  -3.721 0.000199 ***
## mean_pm25                         0.0577309  0.0015390  37.512  < 2e-16 ***
## mean_summer_rm                   -0.0020774  0.0003886  -5.346 8.97e-08 ***
## mean_winter_rm                   -0.0224852  0.0004935 -45.564  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) fc()NC scl(pp) scl(pv) s((_)) scl(p_) s(__20 scl(m_) fct()R
## fctr(ndc)NC -0.102
## scl(ppdnst) -0.009  0.208
## scal(pvrty)  0.041 -0.010 -0.174
## scl(lg(m_))  0.053 -0.018 -0.058   0.862
## scl(pct_bs)  0.056 -0.049  0.167   0.041   0.320
## scl(__2020)  0.064 -0.110  0.246   0.177   0.151 -0.128
## scal(mdn_g)  0.040  0.143  0.005   0.290   0.263  0.139  -0.168
## fctr(prty)R -0.076  0.017 -0.153   0.011  -0.013 -0.082  -0.672 -0.090
## mean_pm25   -0.212 -0.003 -0.380   0.007  -0.084 -0.113   0.051  0.098   0.090
## men_smmr_rm -0.001  0.255  0.046  -0.077  -0.101  0.105  -0.064 -0.106  -0.001
```

```
## men_wntr_rm -0.324 -0.136  0.082   0.003   0.024 -0.118   0.043  0.005  -0.028
##             mn_p25 mn_sm_
## fctr(ndc)NC
## scl(ppdnst)
## scal(pvrty)
## scl(lg(m_))
## scl(pct_bs)
## scl(__2020)
## scal(mdn_g)
## fctr(prty)R
## mean_pm25
## men_smmr_rm -0.230
## men_wntr_rm  0.204 -0.739
## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

Repeat above, - humidity

```
# being edited Model cases
model.initial.cases.nohumidity = glmer(cases ~ (1 | state) + coastal.distance +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.only)
summary(model.initial.cases.nohumidity)

# Model deaths
model.initial.deaths.nohumidity = glmer(deaths ~ (1 | state) + coastal.distance +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.only)
summary(model.initial.deaths.nohumidity)
```

```
# Model cases
model.indicator.cases.nohumidity = glmer(cases ~ (1 | state) + factor(indicatorcoast) +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.indicator.cases.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula:
```

```
## cases ~ (1 | state) + factor(indicatorcoast) + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##       AIC       BIC    logLik  deviance  df.resid
## 1156684.5 1156750.9 -578331.2 1156662.5      3089
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -149.35   -6.90   -0.72    6.05  335.49
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.06264  0.2503
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                  Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                    -2.5868790  0.0357930  -72.273  < 2e-16 ***
## factor(indicatorcoast)NonCoastal -0.0089006  0.0005333  -16.691  < 2e-16 ***
## scale(popdensity)              -0.0016236  0.0001140  -14.241  < 2e-16 ***
## scale(poverty)                  0.0042326  0.0006312    6.705 2.01e-11 ***
## scale(log(median_income))      -0.0591253  0.0005397 -109.545  < 2e-16 ***
## scale(pct_obesity)             -0.0230628  0.0003319  -69.489  < 2e-16 ***
## scale(voter_margin_2020)        0.0857616  0.0004042  212.153  < 2e-16 ***
## scale(median_age)              -0.1053989  0.0003278 -321.540  < 2e-16 ***
## factor(party)Republican        -0.0312698  0.0007187  -43.508  < 2e-16 ***
## mean_pm25                       0.0300463  0.0001900  158.171  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) fc()NC scl(pp) scl(pv) s((_)) scl(p_) s(__20 scl(m_) fct()R
## fctr(ndc)NC -0.013
## scl(ppdnst)  0.016  0.202
## scal(pvrty)  0.000  0.027 -0.166
## scl(lg(m_))  0.002  0.019 -0.088   0.868
## scl(pct_bs)  0.006 -0.083  0.123   0.064   0.328
## scl(__2020)  0.015 -0.088  0.257   0.177   0.170 -0.132
## scal(mdn_g) -0.002  0.197 -0.026   0.294   0.234  0.111  -0.179
## fctr(prty)R -0.022  0.010 -0.135   0.003  -0.033 -0.086  -0.674 -0.076
## mean_pm25   -0.042  0.019 -0.402   0.018  -0.055 -0.078   0.006  0.087   0.120
## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

```r
# Model deaths
model.indicator.deaths.nohumidity = glmer(deaths ~ (1 | state) + factor(indicatorcoast) +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
summary(model.indicator.deaths.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula:
## deaths ~ (1 | state) + factor(indicatorcoast) + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  63864.6  63931.1 -31921.3  63842.6     3089
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -30.294  -1.961  -0.217   1.859  47.558
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1443   0.3799
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                   Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                     -6.7820274  0.0558763 -121.376  < 2e-16 ***
## factor(indicatorcoast)NonCoastal -0.0272076  0.0039199   -6.941 3.89e-12 ***
## scale(popdensity)               -0.0023802  0.0007906   -3.011  0.00261 **
## scale(poverty)                   0.1407018  0.0045468   30.945  < 2e-16 ***
## scale(log(median_income))       -0.1039093  0.0040263  -25.808  < 2e-16 ***
## scale(pct_obesity)              -0.0054653  0.0025089   -2.178  0.02938 *
## scale(voter_margin_2020)         0.0849688  0.0030286   28.056  < 2e-16 ***
## scale(median_age)                0.0820614  0.0024085   34.072  < 2e-16 ***
## factor(party)Republican         -0.0336270  0.0054577   -6.161 7.21e-10 ***
## mean_pm25                        0.0646830  0.0014548   44.462  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) fc()NC scl(pp) scl(pv) s((_)) scl(p_) s(__20 scl(m_) fct()R
## fctr(ndc)NC -0.067
## scl(ppdnst)  0.081  0.195
## scal(pvrty)  0.000  0.015 -0.174
## scl(lg(m_))  0.014  0.012 -0.068   0.862
## scl(pct_bs)  0.030 -0.074  0.165   0.045   0.325
## scl(__2020)  0.073 -0.094  0.269   0.176   0.159 -0.112
## scal(mdn_g) -0.018  0.181  0.006   0.282   0.241  0.134  -0.176
## fctr(prty)R -0.109  0.012 -0.164   0.009  -0.021 -0.094  -0.676 -0.094
## mean_pm25   -0.207  0.033 -0.389   0.011  -0.080 -0.082   0.007  0.109   0.121
## optimizer (Nelder_Mead) convergence code: 0 (OK)
```

```
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

Analysis by region

```
model.byregion.cases = glmer(cases ~ (1 | state) + region + offset(log(population2019)) +
    scale(popdensity) + scale(poverty) + scale(log(median_income)) + scale(pct_obesity) +
    scale(voter_margin_2020) + scale(median_age) + factor(party) + mean_pm25 +
    mean_summer_rm + mean_winter_rm, family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.00368687 (tol = 0.002, component 1)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?;Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
summary(model.byregion.cases)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: cases ~ (1 | state) + region + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##       AIC       BIC    logLik  deviance  df.resid
##  865391.7  865518.6 -432674.9  865349.7      3079
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -95.167  -6.848  -0.626   5.840 313.494
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.07133  0.2671
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                             Estimate Std. Error  z value Pr(>|z|)
## (Intercept)               -1.222e+00  3.839e-02  -31.828  < 2e-16 ***
## regionatlantic             1.229e-01  9.391e-04  130.916  < 2e-16 ***
## regionerie                -8.203e-02  1.447e-03  -56.693  < 2e-16 ***
## regiongreat salt lake      2.729e-01  6.099e-03   44.748  < 2e-16 ***
## regiongulf of mexico      -1.169e-01  9.810e-04 -119.165  < 2e-16 ***
## regionhuron                4.411e-02  3.325e-03   13.265  < 2e-16 ***
## regionmichigan             2.822e-02  1.289e-03   21.894  < 2e-16 ***
## regionontario             -2.698e-01  2.739e-03  -98.492  < 2e-16 ***
## regionpacific              1.296e-01  1.933e-03   67.057  < 2e-16 ***
## regionsuperior             8.109e-02  3.559e-03   22.786  < 2e-16 ***
## scale(popdensity)         -7.537e-03  1.178e-04  -63.958  < 2e-16 ***
## scale(poverty)             2.511e-02  6.498e-04   38.639  < 2e-16 ***
```

```
## scale(log(median_income)) -4.668e-02  5.627e-04  -82.962  < 2e-16 ***
## scale(pct_obesity)        -1.567e-02  3.388e-04  -46.264  < 2e-16 ***
## scale(voter_margin_2020)   7.813e-02  4.075e-04  191.757  < 2e-16 ***
## scale(median_age)         -7.774e-02  3.313e-04 -234.675  < 2e-16 ***
## factor(party)Republican    2.718e-03  7.232e-04    3.758 0.000171 ***
## mean_pm25                  3.566e-02  2.070e-04  172.288  < 2e-16 ***
## mean_summer_rm            -5.660e-03  5.038e-05 -112.340  < 2e-16 ***
## mean_winter_rm            -1.138e-02  6.650e-05 -171.163  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 20 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00368687 (tol = 0.002, component 1)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
## Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
model.byregion.deaths = glmer(deaths ~ (1 | state) + region + offset(log(population2019)) +
    scale(popdensity) + scale(poverty) + scale(log(median_income)) + scale(pct_obesity) +
    scale(voter_margin_2020) + scale(median_age) + factor(party) + mean_pm25 +
    mean_summer_rm + mean_winter_rm, family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.byregion.deaths)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: deaths ~ (1 | state) + region + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  57514.3  57641.2 -28736.2  57472.3     3079
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -19.1837  -1.9368  -0.2376   1.7926  28.3547
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1366   0.3697
```

```
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                              Estimate Std. Error z value Pr(>|z|)
## (Intercept)                -4.9677890  0.0624591 -79.537  < 2e-16 ***
## regionatlantic              0.1226005  0.0069494  17.642  < 2e-16 ***
## regionerie                  0.0655689  0.0100027   6.555 5.56e-11 ***
## regiongreat salt lake      -0.0066083  0.0686426  -0.096 0.923305
## regiongulf of mexico       -0.0449301  0.0071426  -6.290 3.17e-10 ***
## regionhuron                 0.1107717  0.0213068   5.199 2.00e-07 ***
## regionmichigan              0.0198551  0.0096705   2.053 0.040057 *
## regionontario              -0.2573349  0.0199642 -12.890  < 2e-16 ***
## regionpacific               0.2339385  0.0157618  14.842  < 2e-16 ***
## regionsuperior              0.1004552  0.0278334   3.609 0.000307 ***
## scale(popdensity)          -0.0107133  0.0008203 -13.061  < 2e-16 ***
## scale(poverty)              0.1534702  0.0046854  32.755  < 2e-16 ***
## scale(log(median_income)) -0.0978656  0.0042053 -23.272  < 2e-16 ***
## scale(pct_obesity)          0.0054937  0.0025603   2.146 0.031897 *
## scale(voter_margin_2020)    0.0788126  0.0030478  25.859  < 2e-16 ***
## scale(median_age)           0.1051113  0.0024450  42.990  < 2e-16 ***
## factor(party)Republican    -0.0001367  0.0054938  -0.025 0.980147
## mean_pm25                   0.0656813  0.0015911  41.282  < 2e-16 ***
## mean_summer_rm             -0.0024355  0.0003894  -6.255 3.97e-10 ***
## mean_winter_rm             -0.0196499  0.0005151 -38.148  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 20 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

```
model.byregion.cases.nohumidity = glmer(cases ~ (1 | state) + region +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.byregion.cases.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: cases ~ (1 | state) + region + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
```

```
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##       AIC       BIC    logLik  deviance  df.resid
## 1028359.6 1028474.4 -514160.8 1028321.6      3081
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -115.114   -6.958   -0.697    5.667  270.653
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.07216  0.2686
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                               Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                 -2.7103186  0.0384069  -70.568  < 2e-16 ***
## regionatlantic               0.1084636  0.0009293  116.714  < 2e-16 ***
## regionerie                  -0.0891186  0.0014285  -62.387  < 2e-16 ***
## regiongreat salt lake        0.2861851  0.0061052   46.876  < 2e-16 ***
## regiongulf of mexico        -0.1868350  0.0009613 -194.350  < 2e-16 ***
## regionhuron                  0.0164732  0.0033179    4.965 6.87e-07 ***
## regionmichigan               0.0383248  0.0012744   30.073  < 2e-16 ***
## regionontario               -0.3858738  0.0027046 -142.676  < 2e-16 ***
## regionpacific                0.2096797  0.0018563  112.957  < 2e-16 ***
## regionsuperior               0.0476052  0.0035532   13.398  < 2e-16 ***
## scale(popdensity)           -0.0043574  0.0001138  -38.286  < 2e-16 ***
## scale(poverty)              -0.0005081  0.0006432   -0.790     0.43
## scale(log(median_income)) -0.0760590  0.0005530 -137.531  < 2e-16 ***
## scale(pct_obesity)          -0.0199667  0.0003328  -59.990  < 2e-16 ***
## scale(voter_margin_2020)     0.0768644  0.0004047  189.929  < 2e-16 ***
## scale(median_age)           -0.0988561  0.0003257 -303.545  < 2e-16 ***
## factor(party)Republican     -0.0058479  0.0007232   -8.087 6.14e-16 ***
## mean_pm25                    0.0403989  0.0001964  205.684  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

```
model.byregion.deaths.nohumidity = glmer(deaths ~ (1 | state) + region +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
summary(model.byregion.deaths.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: deaths ~ (1 | state) + region + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  61728.1  61842.8 -30845.0  61690.1     3081
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -22.666  -1.957  -0.218   1.779  42.261
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1611   0.4014
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                              Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                -6.9276536  0.0588912 -117.635  < 2e-16 ***
## regionatlantic              0.1156268  0.0068695   16.832  < 2e-16 ***
## regionerie                  0.0427890  0.0098295    4.353 1.34e-05 ***
## regiongreat salt lake      -0.0136530  0.0691390   -0.197  0.84346
## regiongulf of mexico       -0.1269206  0.0069931  -18.149  < 2e-16 ***
## regionhuron                 0.0580125  0.0212224    2.734  0.00627 **
## regionmichigan              0.0108332  0.0095362    1.136  0.25596
## regionontario              -0.3959281  0.0197277  -20.070  < 2e-16 ***
## regionpacific               0.3784439  0.0151642   24.956  < 2e-16 ***
## regionsuperior              0.0689324  0.0277861    2.481  0.01311 *
## scale(popdensity)          -0.0037172  0.0007856   -4.732 2.22e-06 ***
## scale(poverty)              0.1281021  0.0046389   27.615  < 2e-16 ***
## scale(log(median_income)) -0.1242680  0.0041321  -30.074  < 2e-16 ***
## scale(pct_obesity)         -0.0020825  0.0025163   -0.828  0.40788
## scale(voter_margin_2020)    0.0752739  0.0030279   24.860  < 2e-16 ***
## scale(median_age)           0.0853930  0.0024031   35.534  < 2e-16 ***
## factor(party)Republican    -0.0051069  0.0054915   -0.930  0.35239
## mean_pm25                   0.0741647  0.0014994   49.462  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 18 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it
```

```
## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

By region, splitting into Urban and Rural

```
coastal.new$area = ifelse(coastal.new$popdensity >= 1500, "Urban", "Rural")
summary(as.factor(coastal.new$area))
```

```
## Rural Urban
##  3014    86
```

```
coastal.new$regionru = paste(as.character(coastal.new$region), coastal.new$area)
coastal.new$regionru[coastal.new$regionru == "inland Rural"] = "inland"
coastal.new$regionru[coastal.new$regionru == "inland Urban"] = "inland"
coastal.new$regionru = as.factor(coastal.new$regionru)
coastal.new <- within(coastal.new, regionru <- relevel(regionru, ref = "inland"))
summary(coastal.new$regionru)
```

```
##                inland        atlantic Rural        atlantic Urban
##                  2426                   200                    33
##            erie Rural            erie Urban great salt lake Rural
##                    42                     3                    13
##  gulf of mexico Rural  gulf of mexico Urban           huron Rural
##                   126                     3                    25
##        michigan Rural        michigan Urban         ontario Rural
##                    82                     4                    20
##         pacific Rural         pacific Urban        superior Rural
##                    81                     6                    36
```

```
model.byregionru.cases = glmer(cases ~ (1 | state) + regionru + offset(log(population2019)) +
    scale(popdensity) + scale(poverty) + scale(log(median_income)) + scale(pct_obesity) +
    scale(voter_margin_2020) + scale(median_age) + factor(party) + mean_pm25 +
    mean_summer_rm + mean_winter_rm, family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.00348315 (tol = 0.002, component 1)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?;Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
summary(model.byregionru.cases)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: cases ~ (1 | state) + regionru + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
```

```
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##   825880   826037  -412914   825828     3074
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -102.840   -6.800   -0.796    5.751  308.938
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.07569  0.2751
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   -1.206e+00  3.954e-02  -30.50   <2e-16 ***
## regionruatlantic Rural         1.024e-01  9.920e-04  103.23   <2e-16 ***
## regionruatlantic Urban         2.318e-01  1.364e-03  169.93   <2e-16 ***
## regionruerie Rural            -6.567e-02  1.593e-03  -41.23   <2e-16 ***
## regionruerie Urban            -6.483e-02  2.310e-03  -28.06   <2e-16 ***
## regionrugreat salt lake Rural  2.790e-01  6.071e-03   45.95   <2e-16 ***
## regionrugulf of mexico Rural  -9.183e-02  1.111e-03  -82.68   <2e-16 ***
## regionrugulf of mexico Urban  -1.669e-01  1.644e-03 -101.51   <2e-16 ***
## regionruhuron Rural            5.438e-02  3.375e-03   16.11   <2e-16 ***
## regionrumichigan Rural         6.996e-02  1.458e-03   48.00   <2e-16 ***
## regionrumichigan Urban        -2.922e-02  1.810e-03  -16.15   <2e-16 ***
## regionruontario Rural         -2.559e-01  2.780e-03  -92.06   <2e-16 ***
## regionrupacific Rural          8.331e-02  1.964e-03   42.42   <2e-16 ***
## regionrupacific Urban          2.895e-01  2.202e-03  131.51   <2e-16 ***
## regionrusuperior Rural         6.542e-02  3.568e-03   18.34   <2e-16 ***
## scale(popdensity)             -9.222e-03  1.226e-04  -75.19   <2e-16 ***
## scale(poverty)                 1.648e-02  6.572e-04   25.08   <2e-16 ***
## scale(log(median_income))     -5.035e-02  5.714e-04  -88.11   <2e-16 ***
## scale(pct_obesity)            -9.846e-03  3.431e-04  -28.70   <2e-16 ***
## scale(voter_margin_2020)       8.468e-02  4.103e-04  206.37   <2e-16 ***
## scale(median_age)             -8.331e-02  3.357e-04 -248.18   <2e-16 ***
## factor(party)Republican       -2.410e-02  7.433e-04  -32.42   <2e-16 ***
## mean_pm25                      2.702e-02  2.212e-04  122.13   <2e-16 ***
## mean_summer_rm                -8.983e-03  5.569e-05 -161.30   <2e-16 ***
## mean_winter_rm                -7.239e-03  7.160e-05 -101.10   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 25 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00348315 (tol = 0.002, component 1)
## Model is nearly unidentifiable: very large eigenvalue
```

```
##  - Rescale variables?
## Model is nearly unidentifiable: large eigenvalue ratio
##  - Rescale variables?
```

```
model.byregionru.deaths = glmer(deaths ~ (1 | state) + regionru + offset(log(population2019)) +
    scale(popdensity) + scale(poverty) + scale(log(median_income)) + scale(pct_obesity) +
    scale(voter_margin_2020) + scale(median_age) + factor(party) + mean_pm25 +
    mean_summer_rm + mean_winter_rm, family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.00248946 (tol = 0.002, component 1)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.byregionru.deaths)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: deaths ~ (1 | state) + regionru + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25 + mean_summer_rm + mean_winter_rm
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  54292.1  54449.1 -27120.0  54240.1     3074
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -15.9393  -1.9114  -0.2519   1.7376  30.5305
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1556   0.3945
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   -4.9544464  0.0658753 -75.209  < 2e-16 ***
## regionruatlantic Rural         0.0728317  0.0072964   9.982  < 2e-16 ***
## regionruatlantic Urban         0.3656790  0.0096176  38.022  < 2e-16 ***
## regionruerie Rural             0.0079715  0.0111864   0.713   0.4761
## regionruerie Urban             0.2165702  0.0150421  14.398  < 2e-16 ***
## regionrugreat salt lake Rural  0.0188281  0.0677124   0.278   0.7810
## regionrugulf of mexico Rural   0.0164765  0.0079167   2.081   0.0374 *
## regionrugulf of mexico Urban  -0.1812177  0.0125688 -14.418  < 2e-16 ***
## regionruhuron Rural            0.0880927  0.0219042   4.022 5.78e-05 ***
## regionrumichigan Rural        -0.0127230  0.0115325  -1.103   0.2699
## regionrumichigan Urban         0.1349663  0.0134671  10.022  < 2e-16 ***
## regionruontario Rural         -0.2630551  0.0202300 -13.003  < 2e-16 ***
```

```
## regionrupacific Rural          0.1255812  0.0160695   7.815 5.50e-15 ***
## regionrupacific Urban          0.5973271  0.0177448  33.662  < 2e-16 ***
## regionrusuperior Rural         0.0325047  0.0279079   1.165   0.2441
## scale(popdensity)             -0.0164904  0.0008618 -19.135  < 2e-16 ***
## scale(poverty)                 0.1258026  0.0047448  26.514  < 2e-16 ***
## scale(log(median_income))     -0.1121258  0.0042711 -26.252  < 2e-16 ***
## scale(pct_obesity)             0.0169438  0.0025917   6.538 6.25e-11 ***
## scale(voter_margin_2020)       0.1001008  0.0030756  32.547  < 2e-16 ***
## scale(median_age)              0.0890028  0.0024835  35.837  < 2e-16 ***
## factor(party)Republican       -0.0658470  0.0056739 -11.605  < 2e-16 ***
## mean_pm25                      0.0393868  0.0017108  23.022  < 2e-16 ***
## mean_summer_rm                -0.0094007  0.0004384 -21.444  < 2e-16 ***
## mean_winter_rm                -0.0098170  0.0005614 -17.487  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 25 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00248946 (tol = 0.002, component 1)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

```
model.byregionru.cases.nohumidity = glmer(cases ~ (1 | state) + regionru +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.byregionru.cases.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: cases ~ (1 | state) + regionru + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##       AIC       BIC    logLik  deviance  df.resid
##  983384.7  983529.7 -491668.4  983336.7      3076
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -134.540   -7.145   -0.966    5.481  277.329
```

```
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.0681   0.261
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                 Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                    -2.6130585  0.0373207  -70.016  < 2e-16 ***
## regionruatlantic Rural          0.0718281  0.0009850   72.926  < 2e-16 ***
## regionruatlantic Urban          0.2706283  0.0013487  200.666  < 2e-16 ***
## regionruerie Rural             -0.0770886  0.0015769  -48.885  < 2e-16 ***
## regionruerie Urban             -0.0286207  0.0023081  -12.400  < 2e-16 ***
## regionrugreat salt lake Rural   0.3074818  0.0060727   50.633  < 2e-16 ***
## regionrugulf of mexico Rural   -0.1593070  0.0010917 -145.919  < 2e-16 ***
## regionrugulf of mexico Urban   -0.2731059  0.0016203 -168.550  < 2e-16 ***
## regionruhuron Rural             0.0347428  0.0033731   10.300  < 2e-16 ***
## regionrumichigan Rural          0.0739903  0.0014532   50.917  < 2e-16 ***
## regionrumichigan Urban          0.0317921  0.0017929   17.733  < 2e-16 ***
## regionruontario Rural          -0.3347007  0.0027455 -121.910  < 2e-16 ***
## regionrupacific Rural           0.1507014  0.0019232   78.360  < 2e-16 ***
## regionrupacific Urban           0.3033817  0.0020034  151.432  < 2e-16 ***
## regionrusuperior Rural          0.0225314  0.0035637    6.323 2.57e-10 ***
## scale(popdensity)              -0.0083364  0.0001200  -69.444  < 2e-16 ***
## scale(poverty)                 -0.0144068  0.0006496  -22.179  < 2e-16 ***
## scale(log(median_income))      -0.0872588  0.0005594 -155.999  < 2e-16 ***
## scale(pct_obesity)             -0.0144928  0.0003387  -42.784  < 2e-16 ***
## scale(voter_margin_2020)        0.0821106  0.0004061  202.171  < 2e-16 ***
## scale(median_age)              -0.1034755  0.0003313 -312.322  < 2e-16 ***
## factor(party)Republican        -0.0333302  0.0007418  -44.930  < 2e-16 ***
## mean_pm25                       0.0307960  0.0002149  143.303  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 23 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

```
model.byregionru.deaths.nohumidity = glmer(deaths ~ (1 | state) + regionru +
    offset(log(population2019)) + scale(popdensity) + scale(poverty) +
    scale(log(median_income)) + scale(pct_obesity) + scale(voter_margin_2020) +
    scale(median_age) + factor(party) + mean_pm25, family = poisson(link = "log"),
    data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
summary(model.byregionru.deaths.nohumidity)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: poisson  ( log )
## Formula: deaths ~ (1 | state) + regionru + offset(log(population2019)) +
##     scale(popdensity) + scale(poverty) + scale(log(median_income)) +
##     scale(pct_obesity) + scale(voter_margin_2020) + scale(median_age) +
##     factor(party) + mean_pm25
##    Data: coastal.new
##
##      AIC      BIC   logLik deviance df.resid
##  57744.1  57889.0 -28848.1  57696.1     3076
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -18.3636  -1.9628  -0.2932   1.6848  30.5520
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  state  (Intercept) 0.1549   0.3936
## Number of obs: 3100, groups:  state, 49
##
## Fixed effects:
##                                Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                   -6.6171039  0.0581430 -113.807  < 2e-16 ***
## regionruatlantic Rural         0.0449656  0.0072380    6.212 5.22e-10 ***
## regionruatlantic Urban         0.4060703  0.0095067   42.714  < 2e-16 ***
## regionruerie Rural            -0.0120380  0.0110334   -1.091  0.27525
## regionruerie Urban             0.2527065  0.0150281   16.816  < 2e-16 ***
## regionrugreat salt lake Rural  0.0521418  0.0678783    0.768  0.44239
## regionrugulf of mexico Rural  -0.0592621  0.0077627   -7.634 2.27e-14 ***
## regionrugulf of mexico Urban  -0.2985933  0.0123888  -24.102  < 2e-16 ***
## regionruhuron Rural            0.0596786  0.0218748    2.728  0.00637 **
## regionrumichigan Rural        -0.0143170  0.0114874   -1.246  0.21265
## regionrumichigan Urban         0.1964768  0.0133366   14.732  < 2e-16 ***
## regionruontario Rural         -0.3512370  0.0199687  -17.589  < 2e-16 ***
## regionrupacific Rural          0.2072977  0.0157771   13.139  < 2e-16 ***
## regionrupacific Urban          0.6273726  0.0161485   38.850  < 2e-16 ***
## regionrusuperior Rural        -0.0150373  0.0278736   -0.539  0.58955
## scale(popdensity)             -0.0130167  0.0008389  -15.517  < 2e-16 ***
## scale(poverty)                 0.0930799  0.0046906   19.844  < 2e-16 ***
## scale(log(median_income))     -0.1493089  0.0041812  -35.710  < 2e-16 ***
## scale(pct_obesity)             0.0116527  0.0025589    4.554 5.27e-06 ***
## scale(voter_margin_2020)       0.0956861  0.0030446   31.428  < 2e-16 ***
## scale(median_age)              0.0677865  0.0024579   27.580  < 2e-16 ***
## factor(party)Republican       -0.0734747  0.0056668  -12.966  < 2e-16 ***
## mean_pm25                      0.0424584  0.0016518   25.705  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 23 > 12.
```

```
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model is nearly unidentifiable: very large eigenvalue
##  - Rescale variables?
```

Print tables

```
# Run each line individually not all at once
tab_model(model.indicator.cases, digits = 3)
tab_model(model.indicator.deaths, digits = 3)
tab_model(model.indicator.cases.nohumidity, digits = 3)
tab_model(model.indicator.deaths.nohumidity, digits = 3)

tab_model(model.byregion.cases, digits = 3)
tab_model(model.byregion.deaths, digits = 3)
tab_model(model.byregion.cases.nohumidity, digits = 3)
tab_model(model.byregion.deaths.nohumidity, digits = 3)

tab_model(model.byregionru.cases, digits = 3)
tab_model(model.byregionru.deaths, digits = 3)
tab_model(model.byregionru.cases.nohumidity, digits = 3)
tab_model(model.byregionru.deaths.nohumidity, digits = 3)
```

Same Analysis with Our Additional Confounders

```
model.indicator.cases.addconfounders = glmer(cases ~ (1|state) + factor(indicatorcoast) + offset(log(po
                                + scale(log(median_house_value)) + scale(owner_occupied)
                                + scale(blk_pct) + scale(hispanic_pct)
                                + scale(native_pct) + scale(asian_pct)
                                + scale(date_since_social) + scale(date_since)
                                + scale(beds/population.old) + scale(smoke)
                                + scale(mean_pm25)
                                + scale(mean_summer_rm) + scale(mean_winter_rm)
                                + scale(mean_summer_temp) + scale(mean_winter_temp)
                                + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
model.indicator.deaths.addconfounders = glmer(deaths ~ (1|state) + factor(indicatorcoast) + offset(log(
                                + scale(log(median_house_value)) + scale(owner_occupied)
                                + scale(blk_pct) + scale(hispanic_pct)
                                + scale(native_pct) + scale(asian_pct)
                                + scale(date_since_social) + scale(date_since)
                                + scale(beds/population.old) + scale(smoke)
                                + scale(mean_pm25)
                                + scale(mean_summer_rm) + scale(mean_winter_rm)
                                + scale(mean_summer_temp) + scale(mean_winter_temp)
                                + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
model.byregion.cases.addconfounders = glmer(cases ~ (1|state) + region + offset(log(population2019)) + s
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              + scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
model.byregion.deaths.addconfounders = glmer(deaths ~ (1|state) + region + offset(log(population2019)) +
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              + scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
# - humidity
model.indicator.cases.addconfounders.nohumidity = glmer(cases ~ (1|state) + factor(indicatorcoast) + of
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
model.indicator.deaths.addconfounders.nohumidity = glmer(deaths ~ (1|state) + factor(indicatorcoast) + o
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
model.byregion.cases.addconfounders.nohumidity = glmer(cases ~ (1|state) + region + offset(log(populati
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
model.byregion.deaths.addconfounders.nohumidity = glmer(deaths ~ (1|state) + region + offset(log(popula
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
# Analysis by region, rural/urban split
model.byregionru.cases.addconfounders = glmer(cases ~ (1|state) + regionru + offset(log(population2019)
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              + scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unider
##  - Rescale variables?
```

```
model.byregionru.deaths.addconfounders = glmer(deaths ~ (1|state) + regionru + offset(log(population201
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
```

```
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              + scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
model.byregionru.cases.addconfounders.nohumidity = glmer(cases ~ (1|state) + regionru + offset(log(popul
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

```
model.byregionru.deaths.addconfounders.nohumidity = glmer(deaths ~ (1|state) + regionru + offset(log(po
                              + scale(log(median_house_value)) + scale(owner_occupied)
                              + scale(blk_pct) + scale(hispanic_pct)
                              + scale(native_pct) + scale(asian_pct)
                              + scale(date_since_social) + scale(date_since)
                              + scale(beds/population.old) + scale(smoke)
                              + scale(mean_pm25)
                              #+ scale(mean_summer_rm) + scale(mean_winter_rm)
                              + scale(mean_summer_temp) + scale(mean_winter_temp)
                              + scale(no_grad), family = poisson(link = "log"), data = coastal.new)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model is nearly unide
##  - Rescale variables?
```

Printing tables

```
# Run each line individually not all at once
tab_model(model.indicator.cases.addconfounders, digits = 3)
tab_model(model.indicator.cases.addconfounders.nohumidity, digits = 3)
tab_model(model.indicator.deaths.addconfounders, digits = 3)
tab_model(model.indicator.deaths.addconfounders.nohumidity, digits = 3)

tab_model(model.byregion.cases.addconfounders, digits = 3)
tab_model(model.byregion.cases.addconfounders.nohumidity, digits = 3)
tab_model(model.byregion.deaths.addconfounders, digits = 3)
tab_model(model.byregion.deaths.addconfounders.nohumidity, digits = 3)
```

```
tab_model(model.byregionru.cases.addconfounders, digits = 3)
tab_model(model.byregionru.cases.addconfounders.nohumidity, digits = 3)
tab_model(model.byregionru.deaths.addconfounders, digits = 3)
tab_model(model.byregionru.deaths.addconfounders.nohumidity, digits = 3)
```