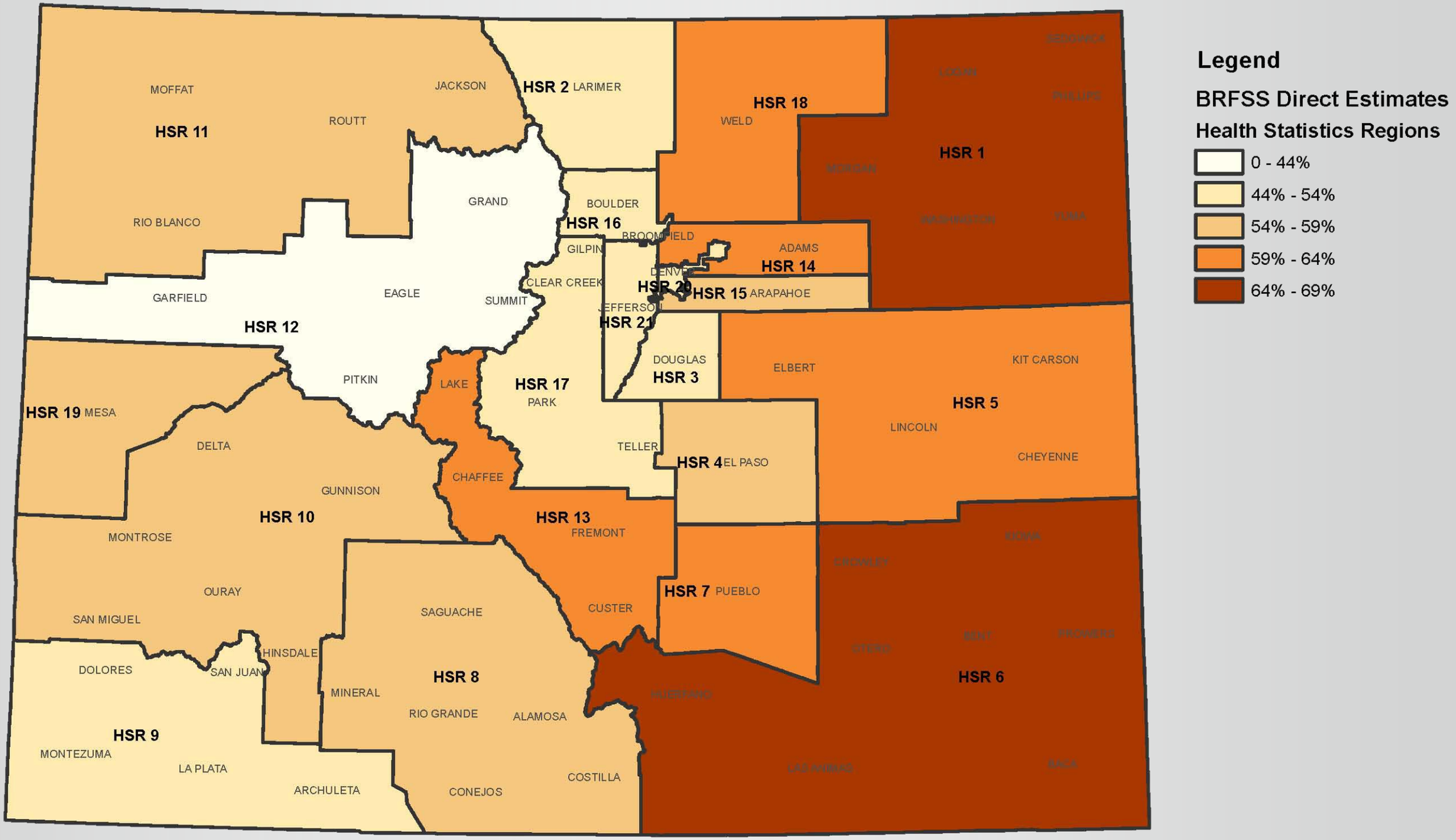
Developing Census Tract Level BMI Estimates Using BRFSS and Census Data

COLORADO
Department of Public Health & Environment

Overview

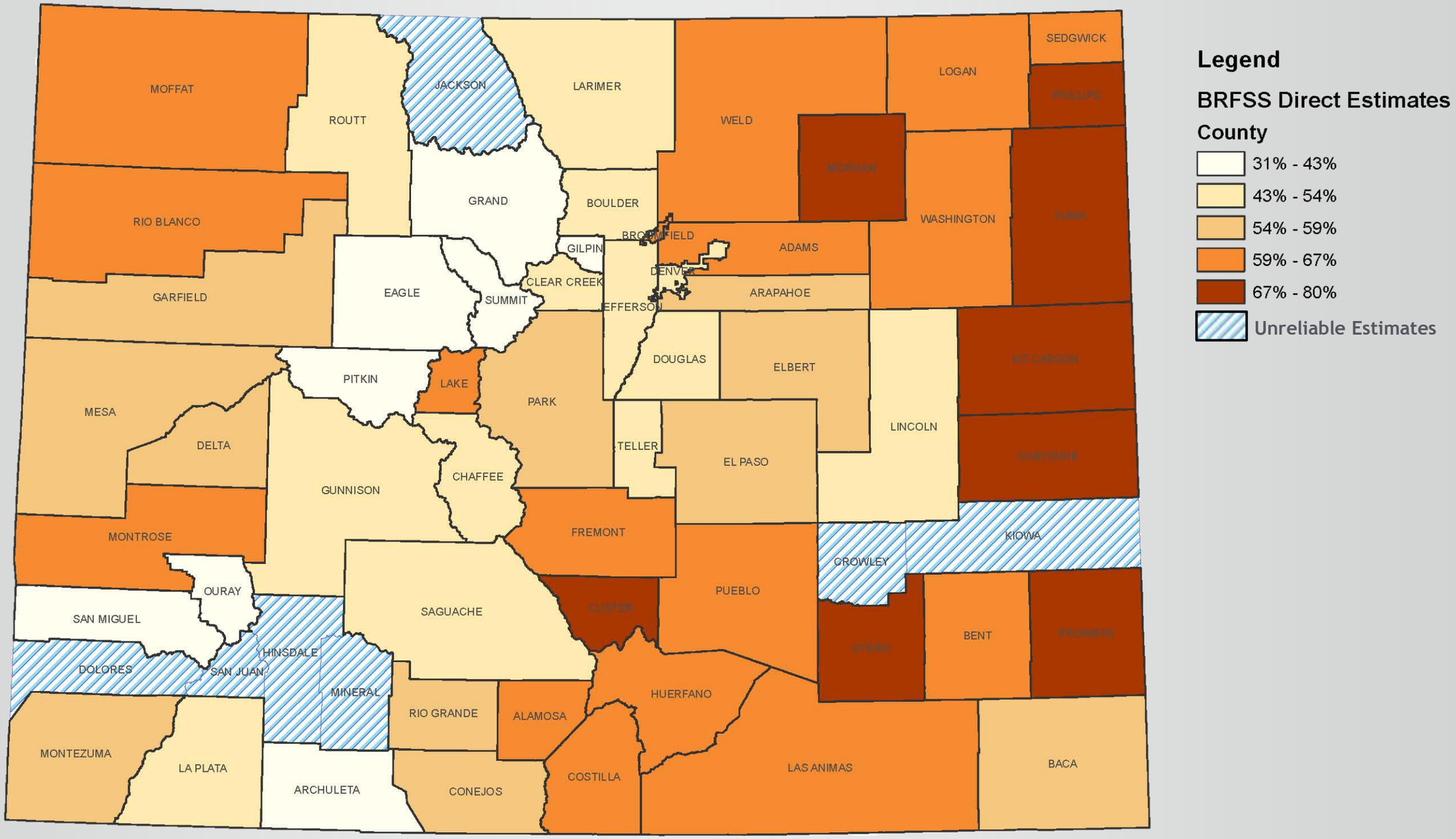
- Where We Started Out/Why are we doing this?
- High Level Overview of How We Developed Census Tract Level BMI Estimates
- Examples of the Data



COLORADO
Department of Public Health & Environment

Previous Data Level: Health Statistics Regions

BRFSS Direct Estimates 2011-2014



COLORADO
Department of Public Health & Environment

Previous Data Level: Counties

BRFSS Direct Estimates 2011-2014

Is there a way to get complete data at a local level?

CDPHE COLORADO
Department of Public Health & Environment

Statistical Models!

$$n! \approx \left(\frac{n}{e}\right)^n \cdot \sqrt{2\pi n}$$

$$A_n^k = \frac{n!}{(n-k)!}$$

$$A_n^k = n \cdot (n-1) \cdot (n-2) \cdot \ldots \cdot (n-k+1)$$

$$\tilde{A}_n^k = \underbrace{n \cdot n \cdot \ldots \cdot n}_{k} = n^k$$

$$C_r = \frac{n!}{(n-n)!} = \frac{n!}{0!}$$

$$\tilde{P}_{n_1, n_2, \ldots, n_k} = \frac{(n_1 + n_2 + \ldots + n_k)!}{n_1! n_2! \ldots n_k!}$$

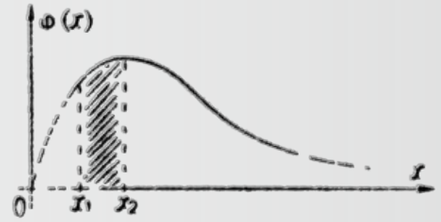
$$C_n^k = \frac{n!}{k!(n-k)!}$$

$$\tilde{C}_n^m = P_{m, n-1} = \frac{(n+m-1)!}{m!(n-1)!}$$

$$(a+b)^n = C_n^0 a^n + C_n^1 a^{n-1} b^1 + \ldots + C_n^{n-1} a^1 b^{n-1} + C_n^n b^n = \sum_{k=0}^{n} C_n^k a^{n-k} b^k$$

$$p(B) = p(B|A_1)p(A_1) + p(B|A_2)p(A_2) + p(B|A_3)p(A_3) + \ldots + p(B|A_k)p(A_k)$$

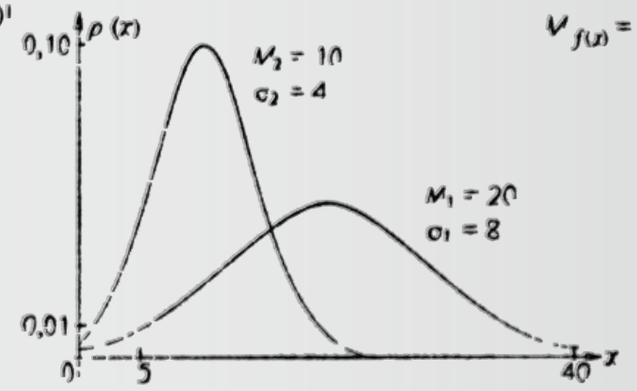
$$p(x) = \frac{p(B|A_1)p(A_1)}{p(B|A_1)p(A_1) + p(B|A_2)p(A_2) + \ldots + p(B|A_k)\bar{p}(\bar{A}_k)}$$



$$D_x = \int_{-\infty}^{+\infty} (x - M_x)^2 \varphi(x)\, dx$$

$$M_x = \int_{-\infty}^{+\infty} x \varphi(x)\, dx$$

$$M_{f(x)} = \int_{-\infty}^{+\infty} f(x) \varphi(x)\, dx$$

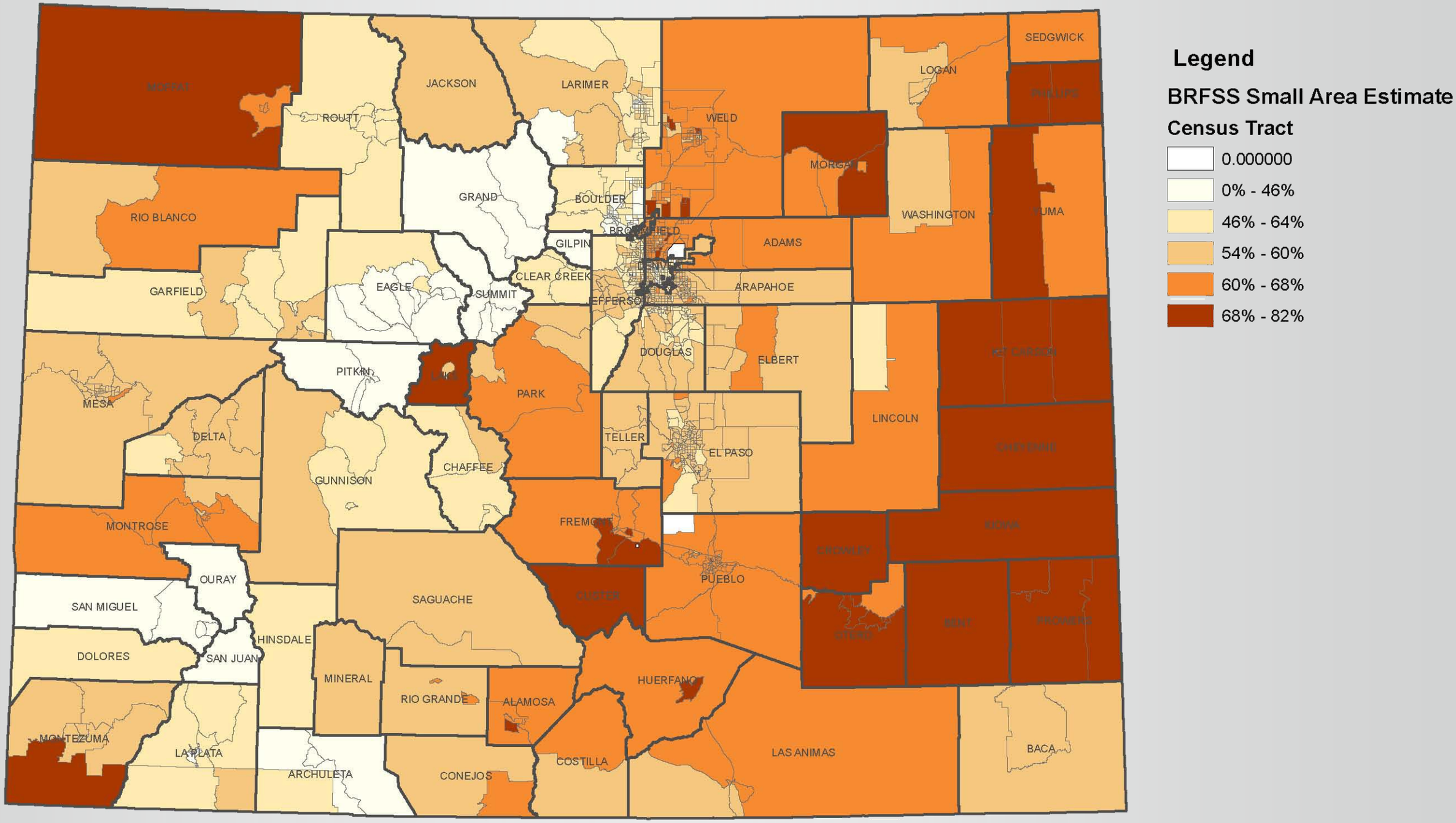


$$S = v_0 t + \frac{at^2}{2}$$

$$F = G\frac{m_1 m_2}{R^2}$$

$$f(v) = 4\pi\left(\frac{m_0}{2\pi kT}\right)^{3/2} v^2 e^{\frac{-m_0 v^2}{2kT}}$$

COLORADO
Department of Public Health & Environment

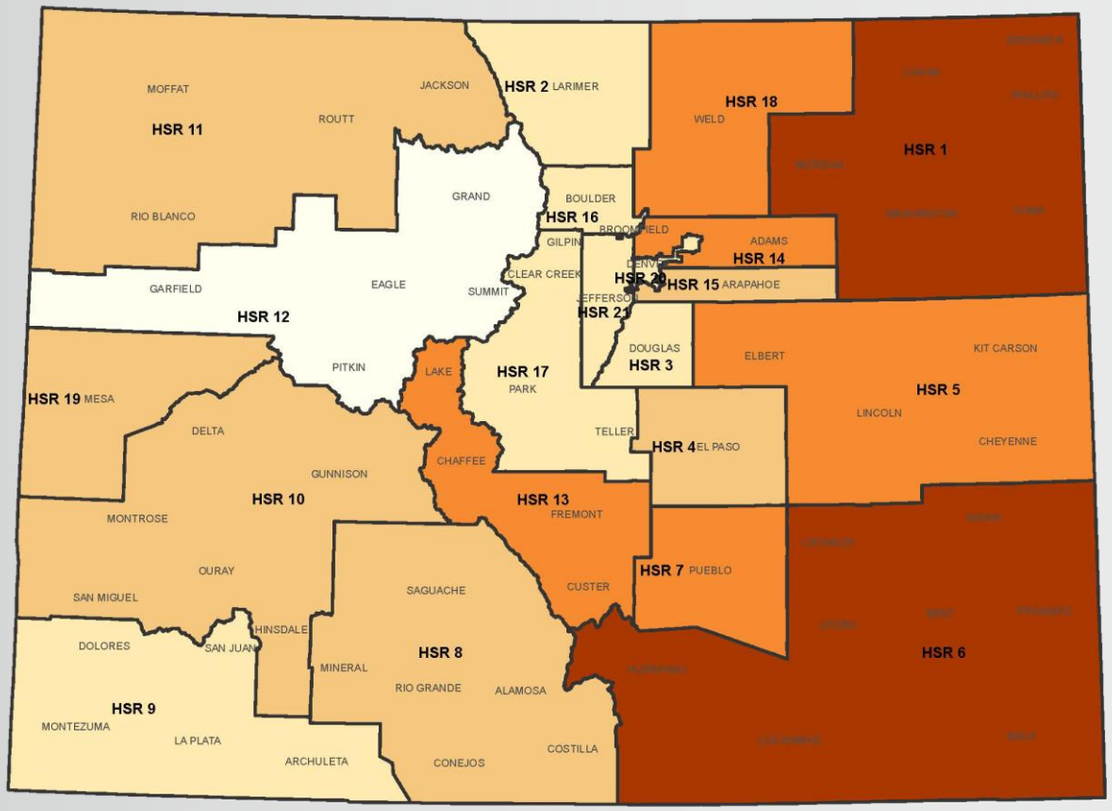


COLORADO
Department of Public Health & Environment

Census Tract (1249):

Small Area Model Based Estimates 2011-2014

BRFSS HSR Direct Estimates 2011-2013

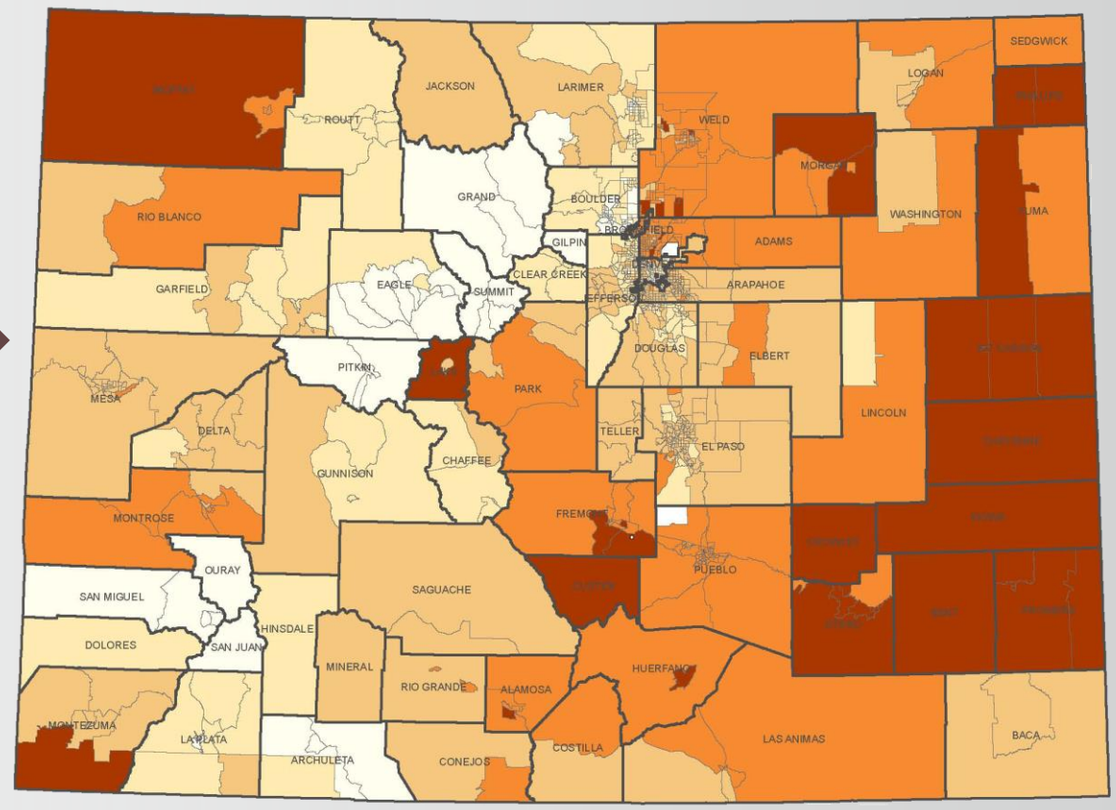


BRFSS Direct Estimates
Health Statistics Regions

- 0 - 44%
- 44% - 54%
- 54% - 59%
- 59% - 64%
- 64% - 69%

Small Area Estimates

based on BRFSS direct estimates 2011-2013



BRFSS Small Area Estimate
Census Tract

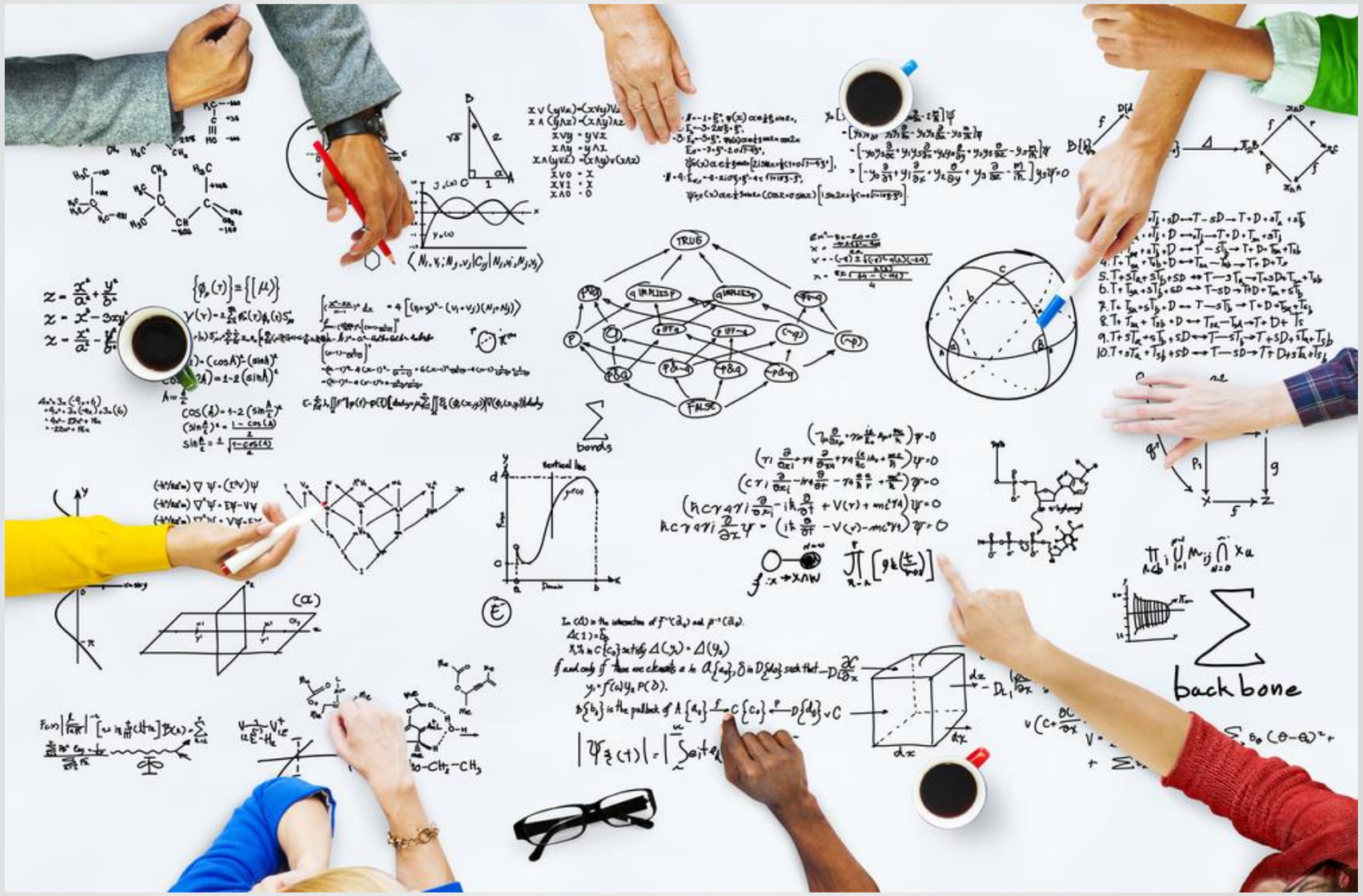
- 0.000000
- 0% - 46%
- 46% - 64%
- 54% - 60%
- 60% - 68%
- 68% - 82%

COLORADO
Department of Public Health & Environment

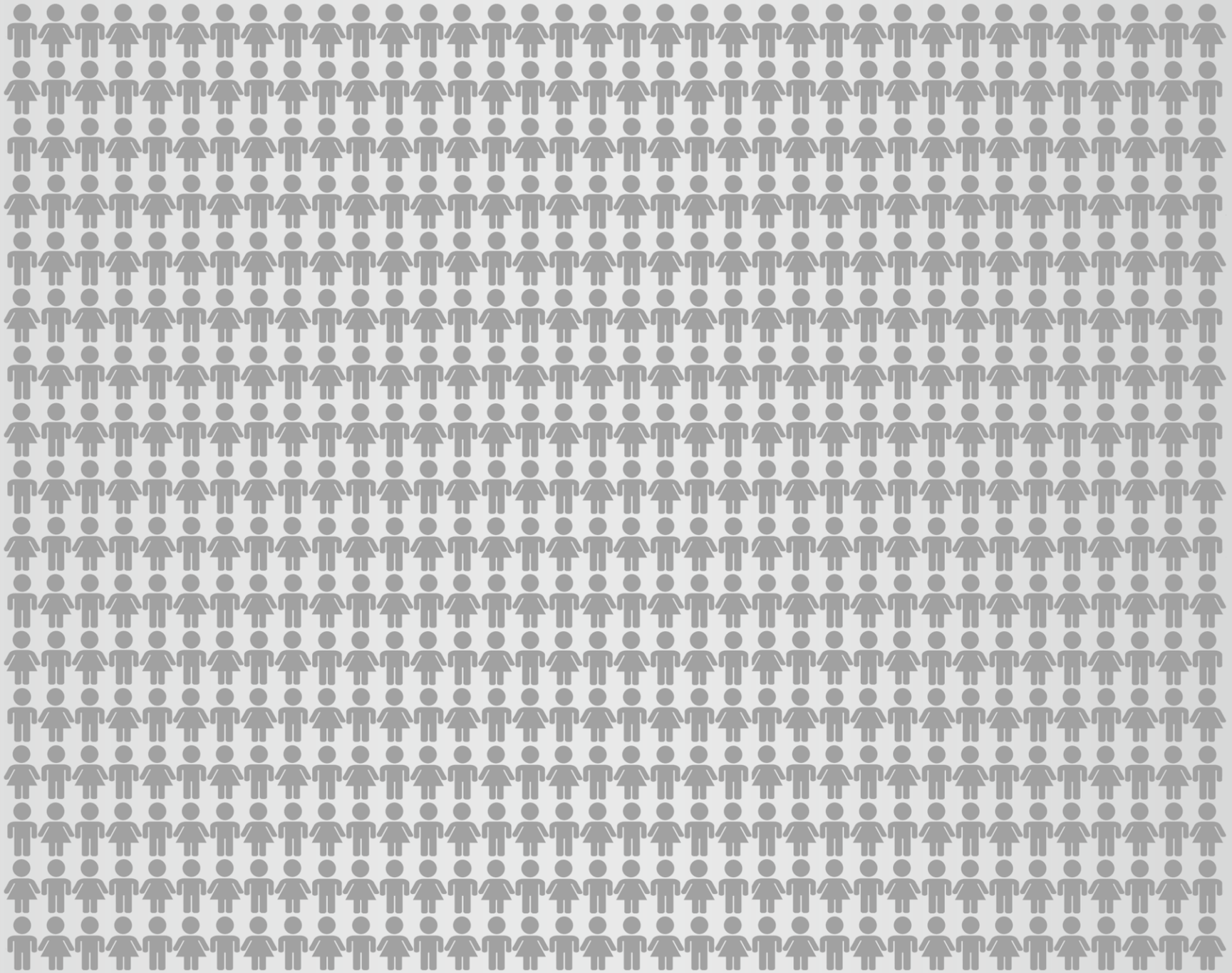
Census Tract (1249):

Model Based Estimates 2011-2014

How did we develop this data?



COLORADO
Department of Public Health & Environment



COLORADO
Department of Public Health & Environment

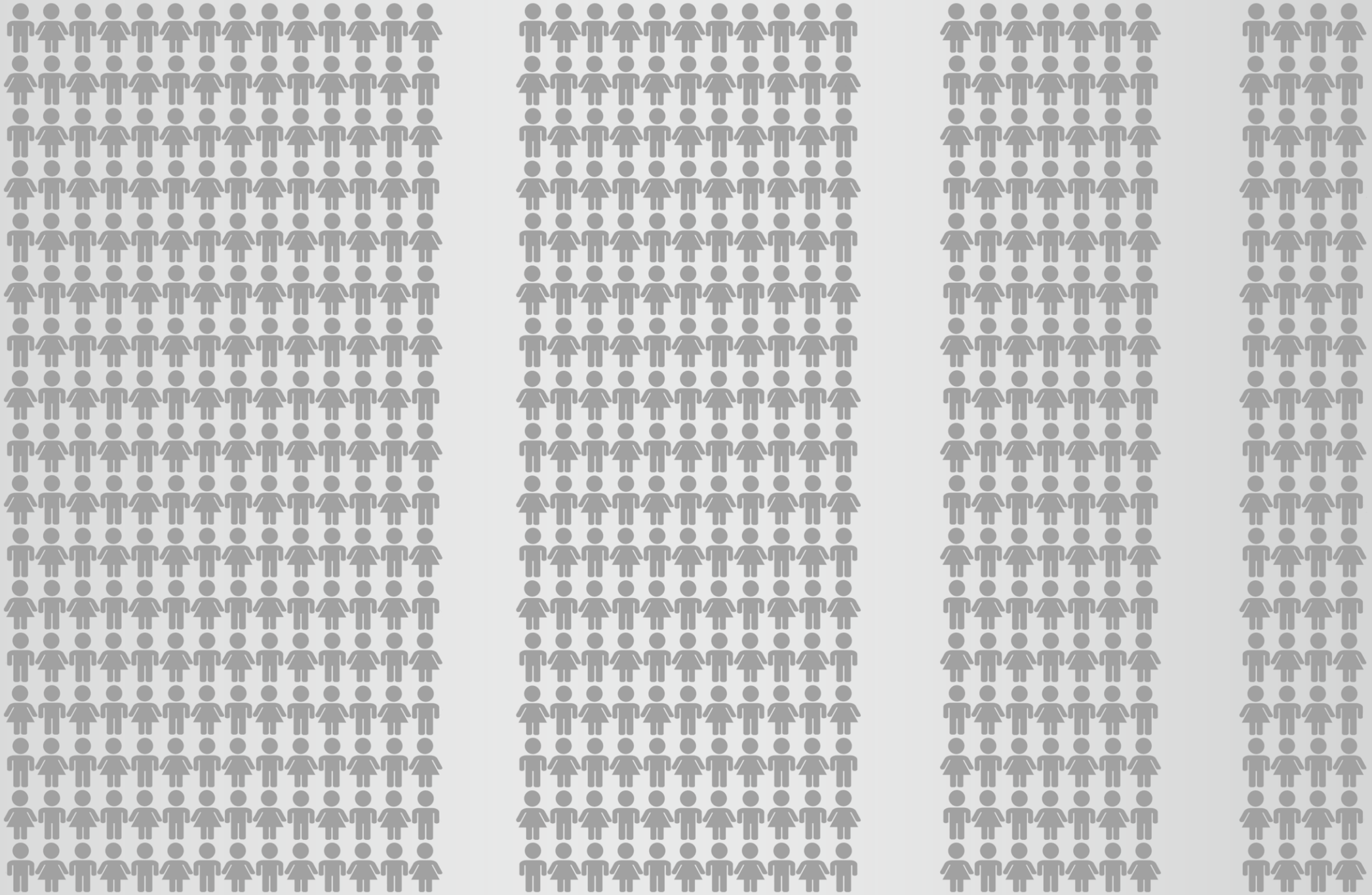
Colorado BRFSS Respondents (Representative of Adult Coloradoans)

Demographic 1

Demographic 2

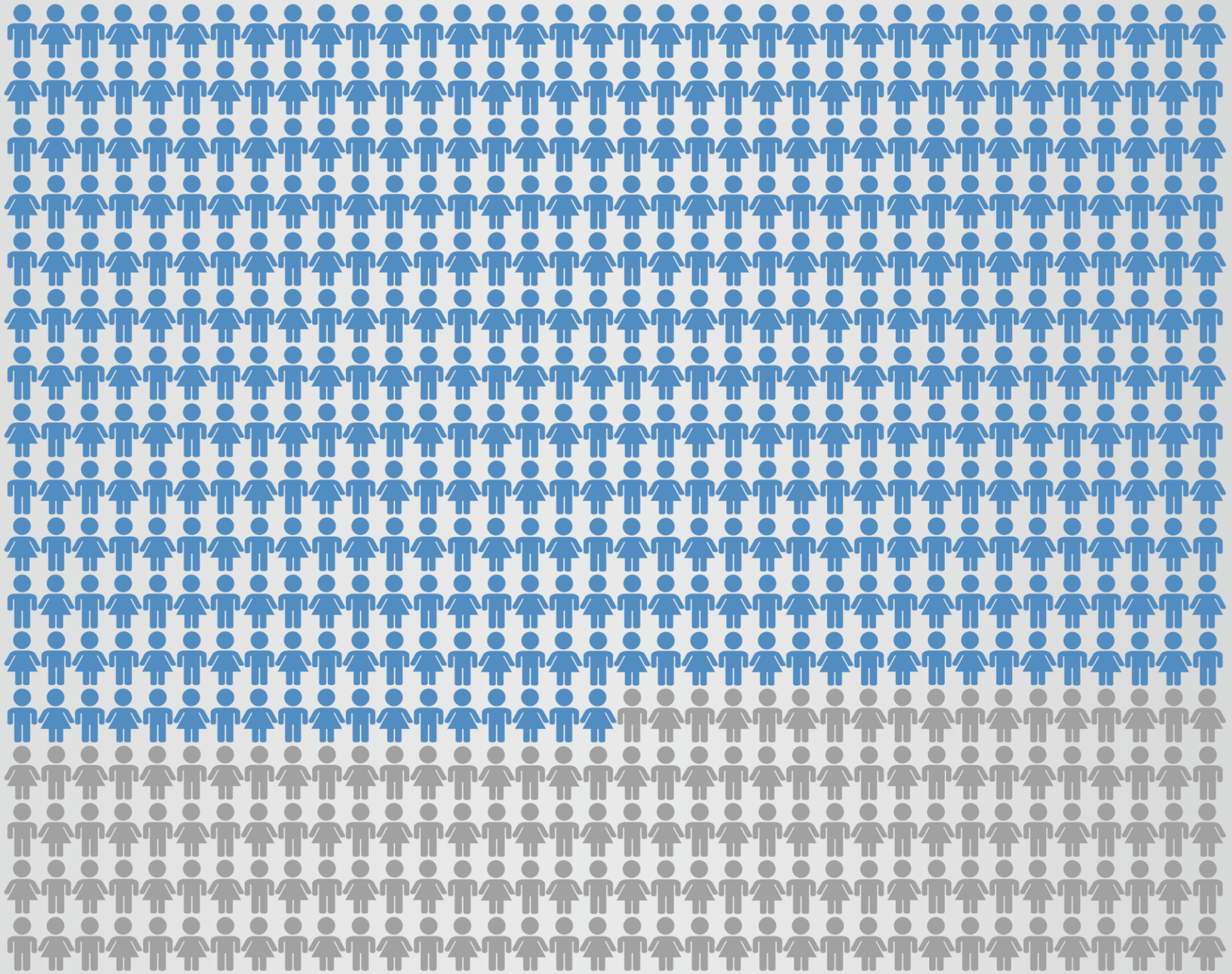
Demographic 3

Demographic 4



COLORADO
Department of Public Health & Environment

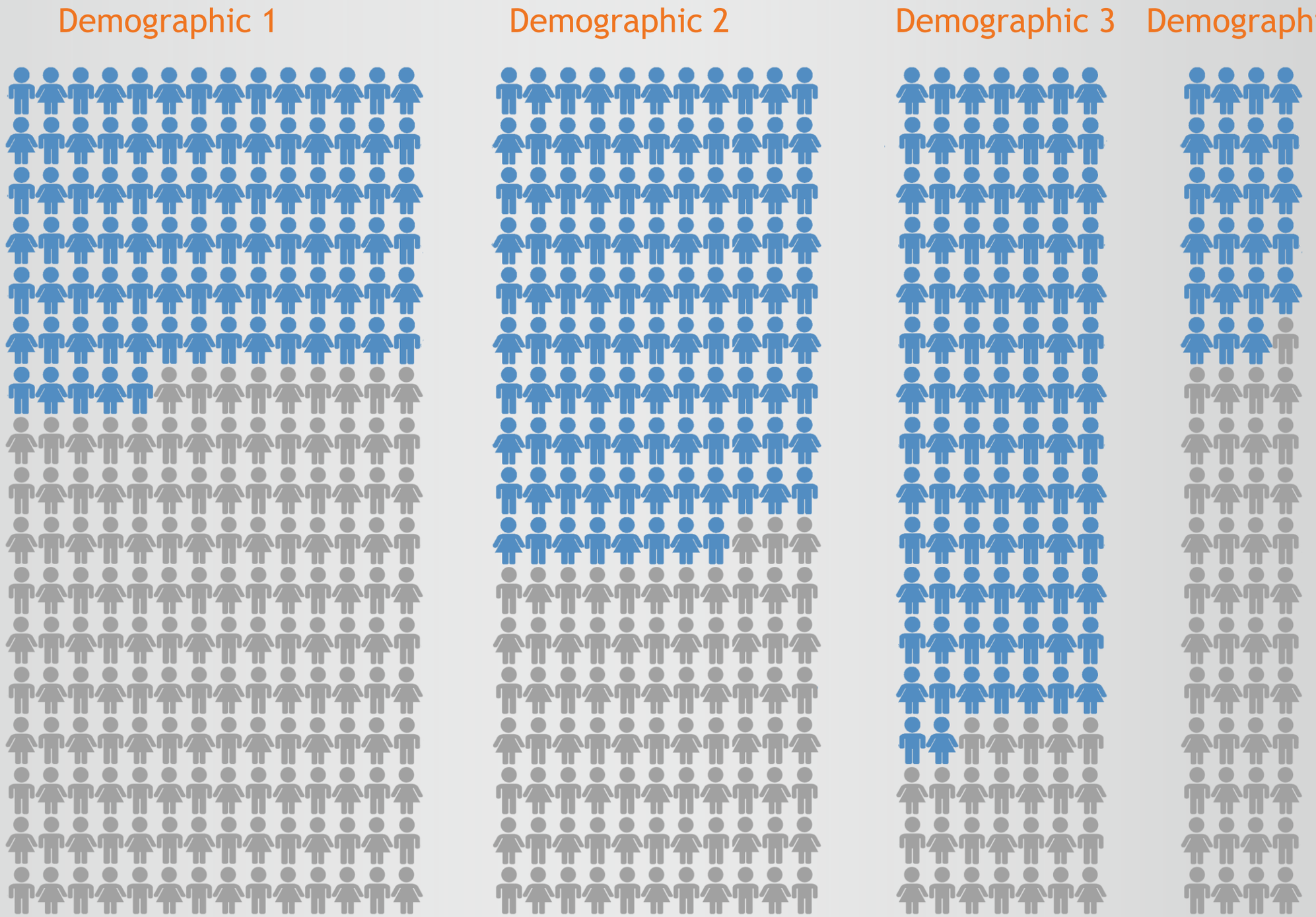
Colorado BRFSS Respondents: Categorized by Self-Reported Age/Race/Gender (24 Groups)



Blue = BMI >25 | Grey = BMI <25 (self reported height x weight)

COLORADO
Department of Public Health & Environment

Colorado BRFSS Respondents: BMI Status (Representative of Adult Coloradoans)



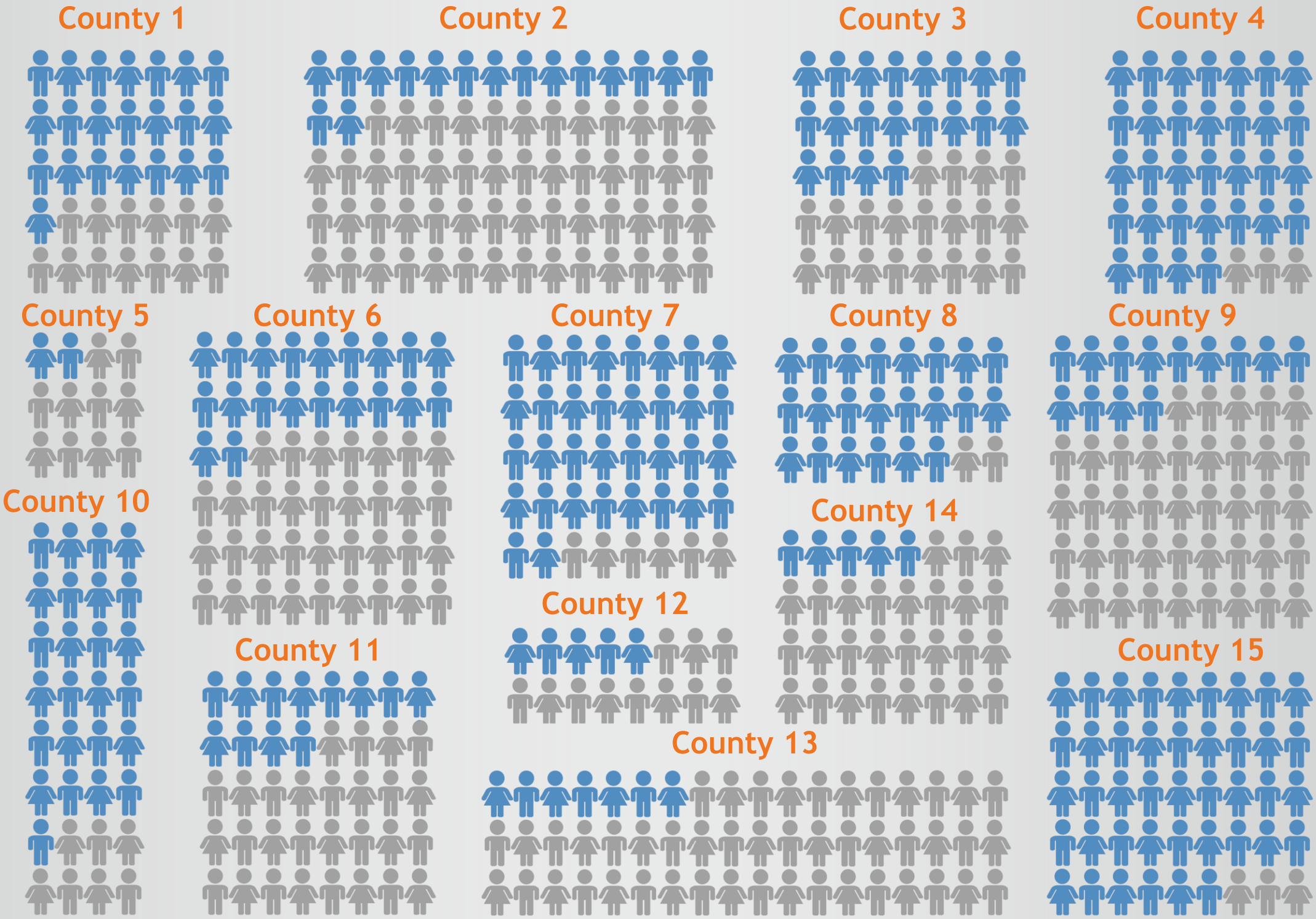
Blue = BMI >25 | Grey = BMI <25 (self reported height x weight)

COLORADO
Department of Public Health & Environment

Colorado BRFSS Respondents by Age/Race/Gender Group and BMI Status

COLORADO
Department of Public Health & Environment

Colorado BRFSS Respondents by County of Residence (Imputed from ZIP)



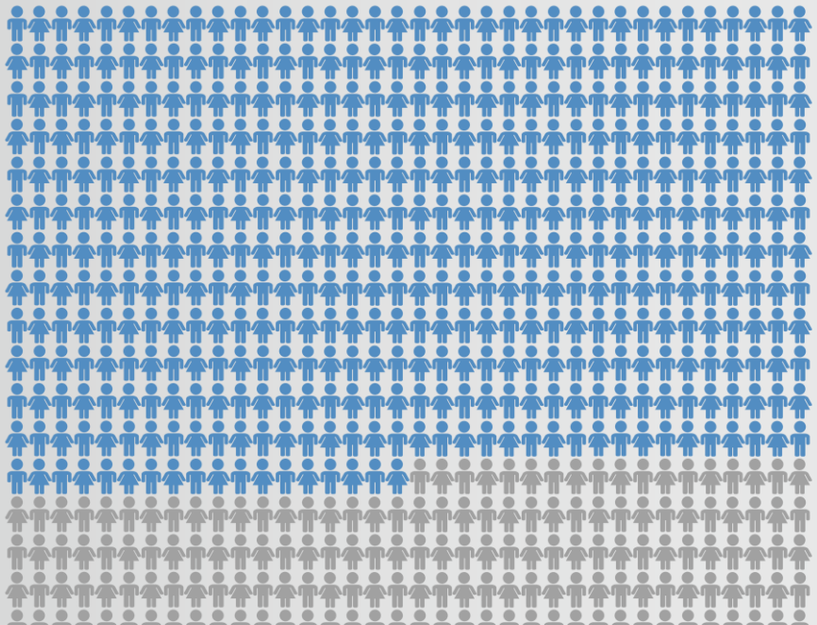
COLORADO
Department of Public Health & Environment

Colorado BRFSS Respondents by County of Residence and BMI Status

How do we fit this data to a model?

COLORADO
Department of Public Health & Environment

Individual CO-BRFSS Respondent Level



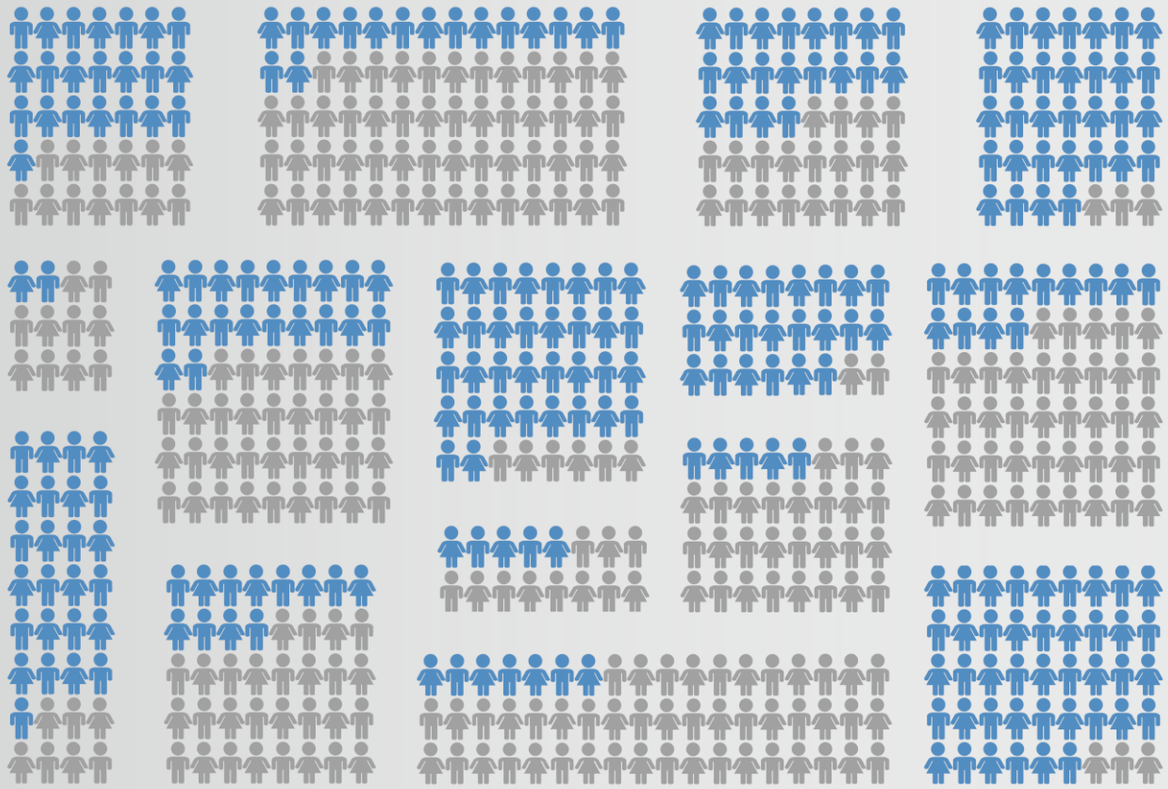
- Demographic
  Age/Race/Gender Group
- BMI >25

= Obese/Not Obese

COLORADO
Department of Public Health & Environment

Multi-Level Model: Individual Level

County Level



- County-Level Poverty
- County-Level Education Attainment

COLORADO
Department of Public Health & Environment

Multi-Level Model: Group Level

Outcome = Individual Level + Group Level

Height x Weight	Individual BRFSS ~39,000	Counties 64
• Yes/No Overweight/Obese	• Race • Age • Gender	• County • Poverty • Education

Interaction Term:

County x Race/Age/Gender

Generalized Linear Multi-Level Regression

$$\eta_{ij} = \gamma_{00} + \gamma_{10} X_{ij} + \gamma_{01} W_j + u_{0j}$$

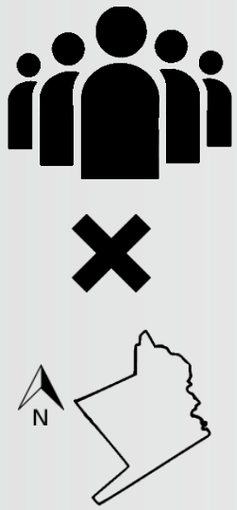
a.k.a

“mixed-level models”
“hierarchical models”
“random effects models”
“nested data models”

COLORADO
Department of Public Health & Environment

Generalized Linear Multilevel Model

Census Tract Level Estimate Creation



24 Age/Race/Gender Group
County-Level Multi-level Modeled Obesity Probability

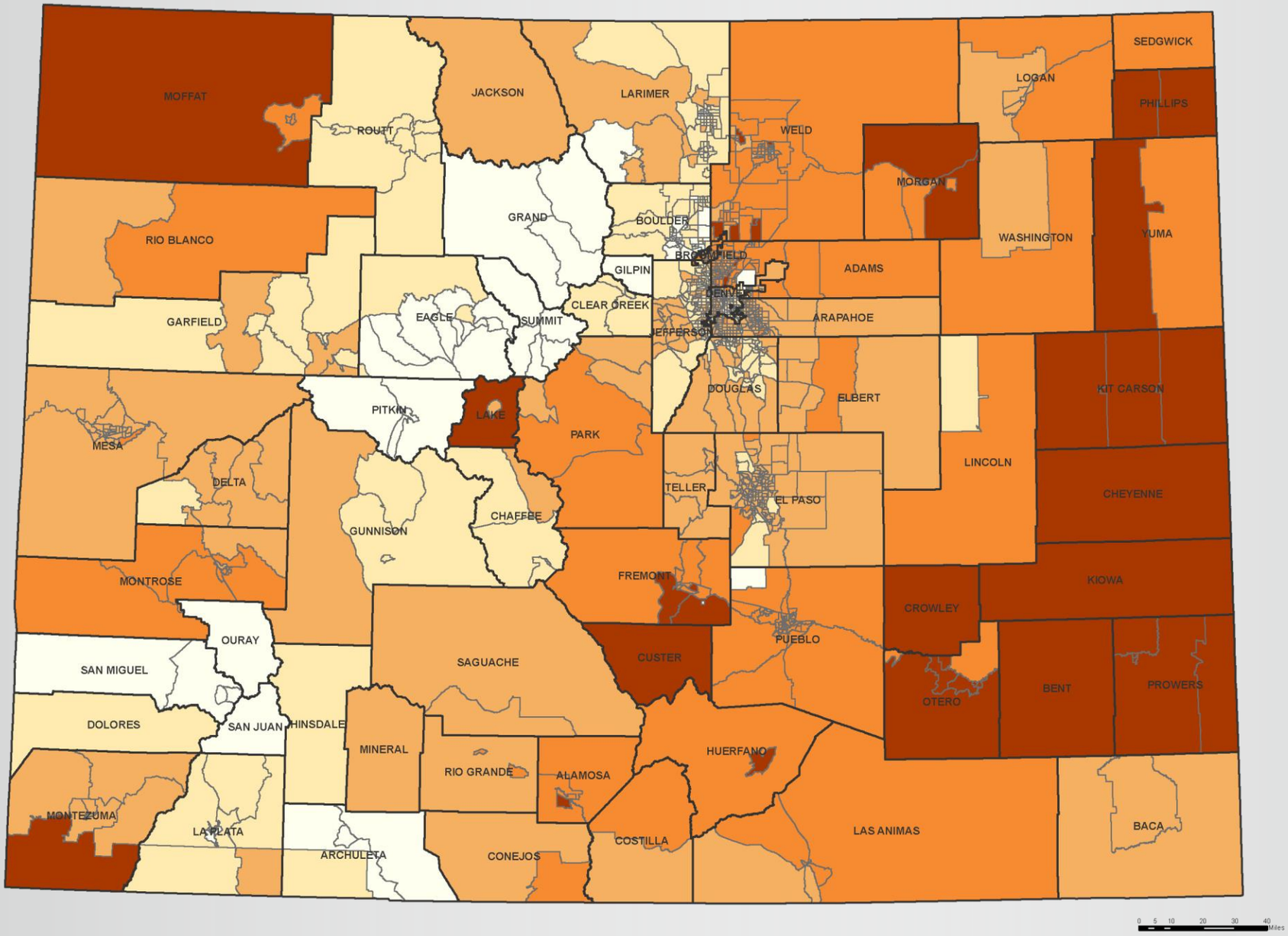
ACS 5yr- Derived Census Tract Age/Race/Gender Group
Population Counts

Summed 24 Group Obesity Estimates
/ Total Tract 18+ Adult Population

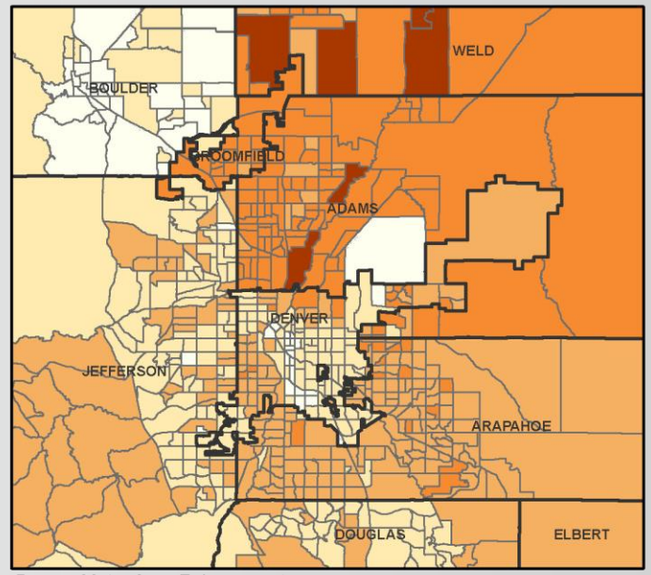
Census Tract Level Obesity Estimate

COLORADO
Department of Public Health & Environment

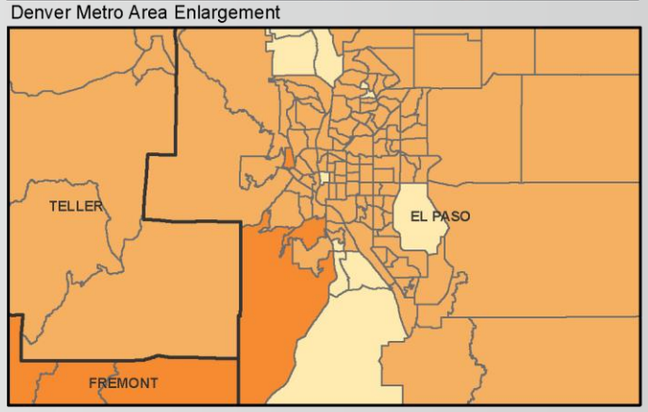
Generalized Linear Multilevel Model



State of Colorado by Census Tract



Denver Metro Area Enlargement



El Paso County Enlargement

Legend

BMI >25.0: Small Area Estimate
***Percent Overweight/Obese**

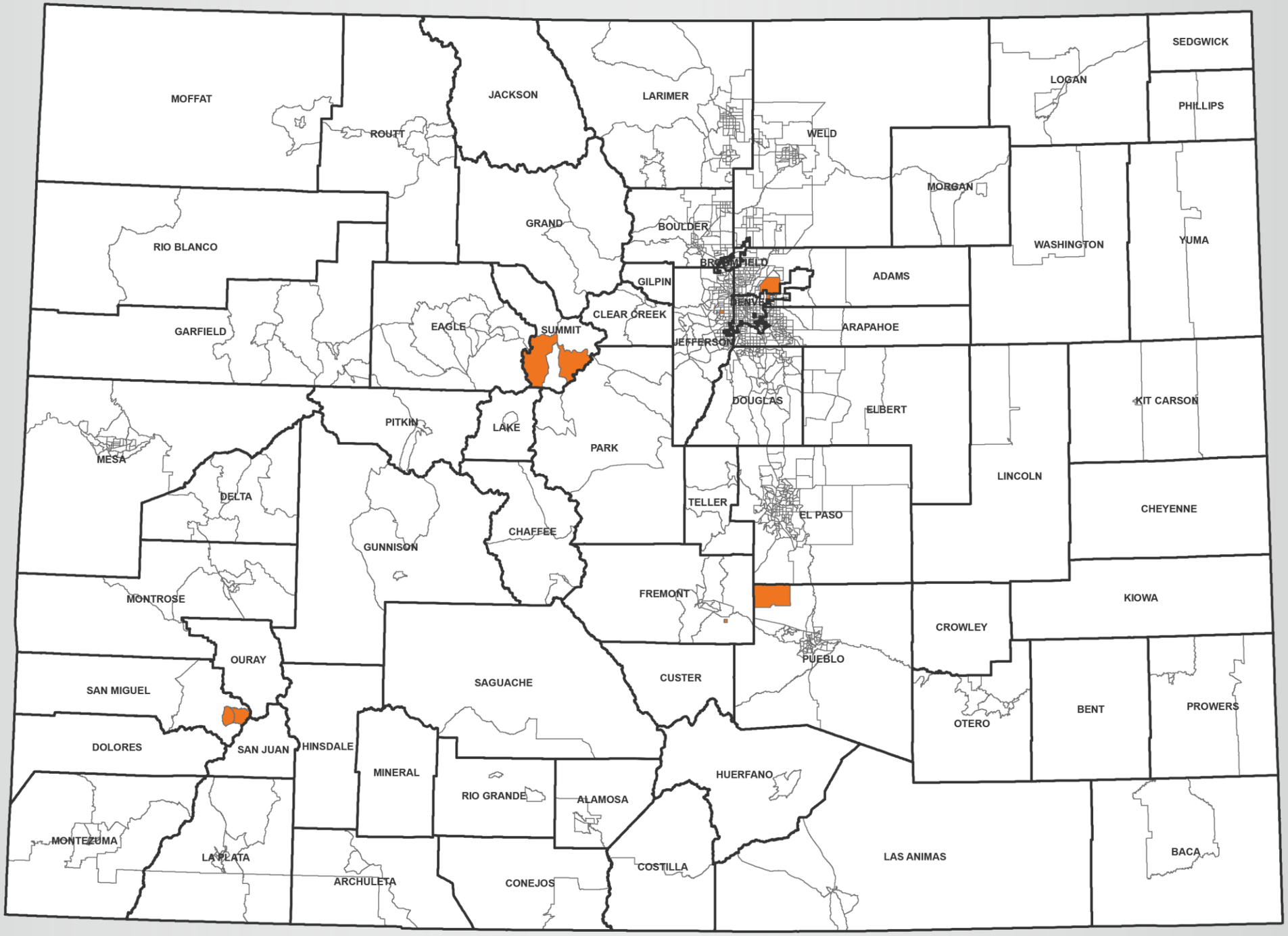
- 0 - 46%
- 46% - 54%
- 54% - 60%
- 60% - 68%
- 68% - 82%

* Catagories based on natural breaks

COLORADO
Department of Public Health & Environment

Results: Census Tract (1249)

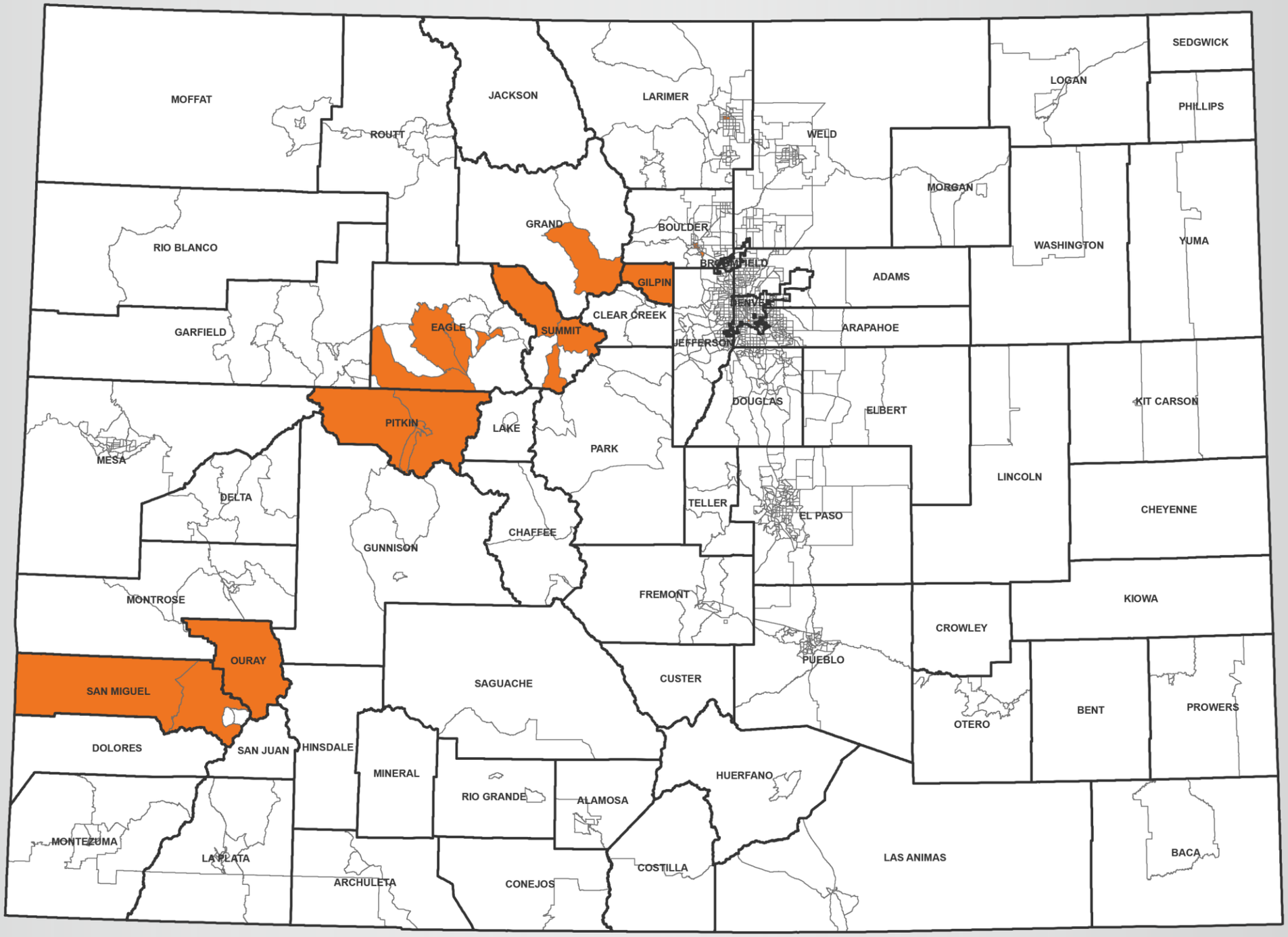
Small Area Model Based Estimates 2011-2014



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: <30%

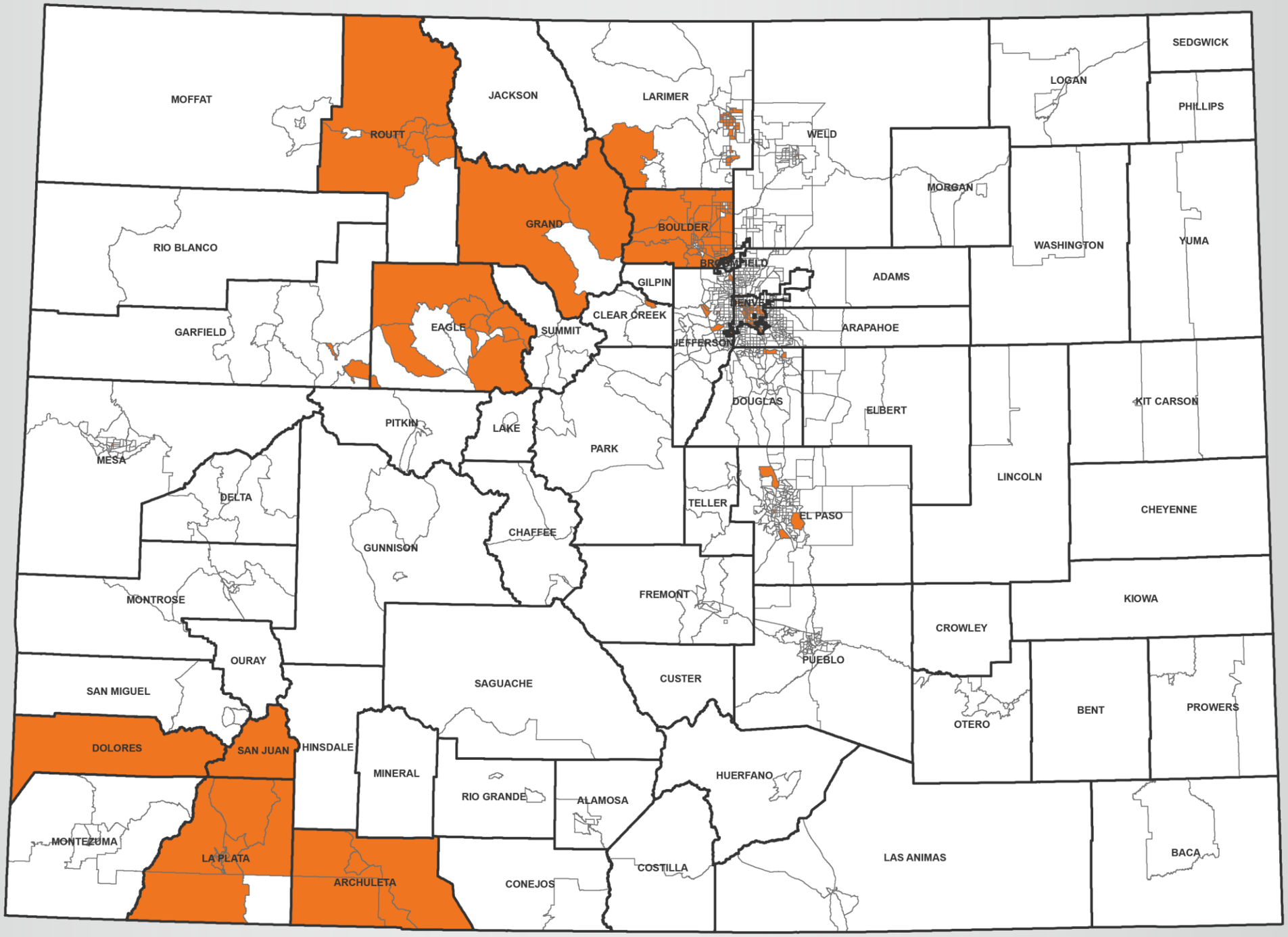
Census Tracts (13 of 1249)



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: 30%-40%

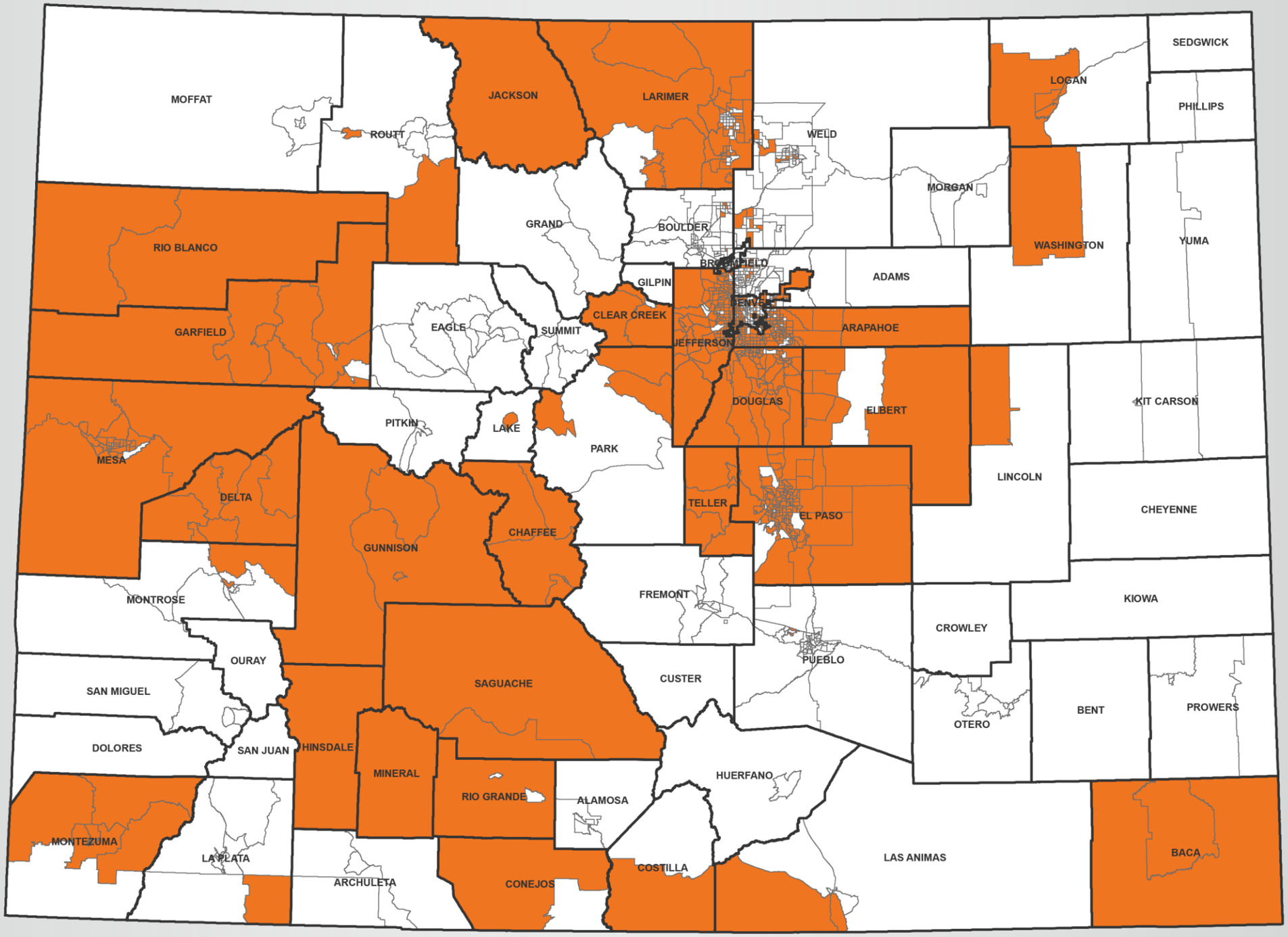
Census Tracts (27 of 1249)



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: 40%-50%

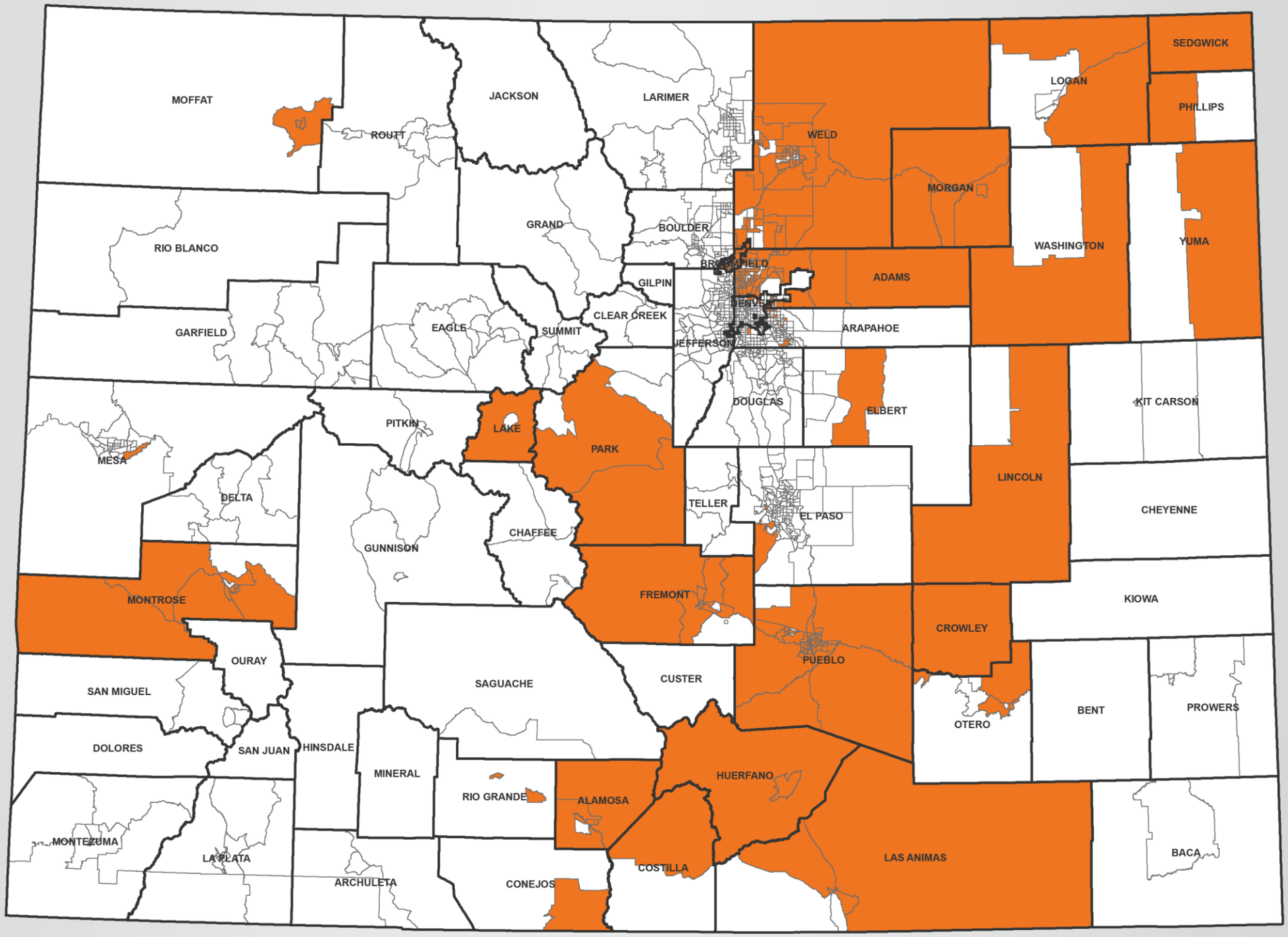
Census Tracts (199 of 1249)



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: 50%-60%

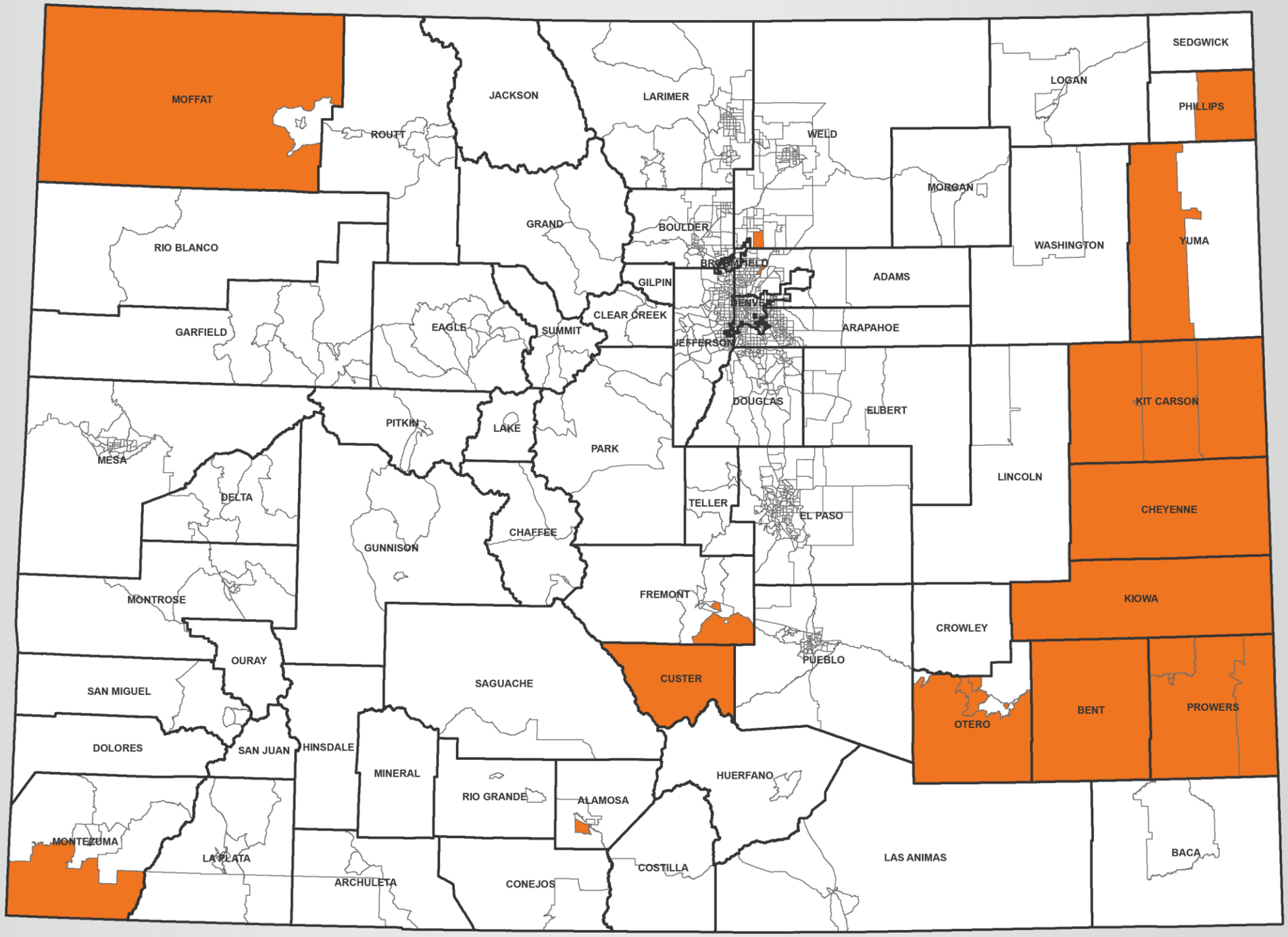
Census Tracts (689 of 1249)



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: 60%-70%

Census Tracts (294 of 1249)



COLORADO
Department of Public Health & Environment

BMI >25.0 Small Area Estimates: 70%+

Census Tracts (27 of 1249)

Current health surveillance systems struggle to generate health outcome estimates at geographies smaller than the state level. Some states, such as Colorado, have expanded sampling to develop reliable county level health estimates. However even within counties, there is considerable variability that may occur and a county level estimate may not provide enough detail. Smaller geographies, such as census tracts, are often needed to understand the degree of a problem and hone in on specific populations.

Small area models are statistical models used to generate health outcome estimates at a geography smaller than possible with traditional surveillance methods. In examining BMI outcomes (overweight/ obese), we fit a multilevel model using individual Behavioral Risk Factor Surveillance System (BRFSS) data in addition to socio-demographic and contextual information from the U.S. Census (ACS). Individuals' results are nested within geographic boundaries (counties) where both individual characteristics (demographic) as well as location characteristics are used to model the probability of being overweight/ obese. We can begin to account for the variability occurring between groups and locations by incorporating random effects into the model.

The multilevel model we use is a generalized linear mixed multilevel model. We model individual level BRFSS weighted survey responses 2011-2013 (n=36,719) grouped within counties (n=64) and demographic groups (n=24). The outcome variable Overweight and/or Obese (Yes/No) was based on self reported height and weight from individual survey responses. With SAS 9.3 we run PROC GLIMMIX to calculate an odds ratio and predicted probability for each demographic group (age*race*sex) for each county. Using 2009-2013 American Community Survey 5-Year Estimates for census tracts stratified by age, race and gender; we use the county demographic group predicted probabilities to calculate the estimated number of individuals who are overweight/obese (this calculation is based on the assumption that age group # in county # will have the same outcome throughout the census tracts within that county).

The model was estimated using the LaPlace estimation based on examples from previously documented SAE. We evaluate model fit using a likelihood ratio test (~chi- square difference) comparing values in -2Log Likelihood values. We also evaluate differences in AIC and BIC values between models. The predicted probabilities are estimated from covariate data from all the counties, not just from a single county. The use of all available data to model BMI leads to an increase in the effective sample size for a given area allowing for estimates for geographies with limited survey data available.

COLORADO
Department of Public Health & Environment

Summary

Questions?

cdphe.healthstatistics@state.co.us

CDPHE COLORADO
Department of Public Health & Environment