

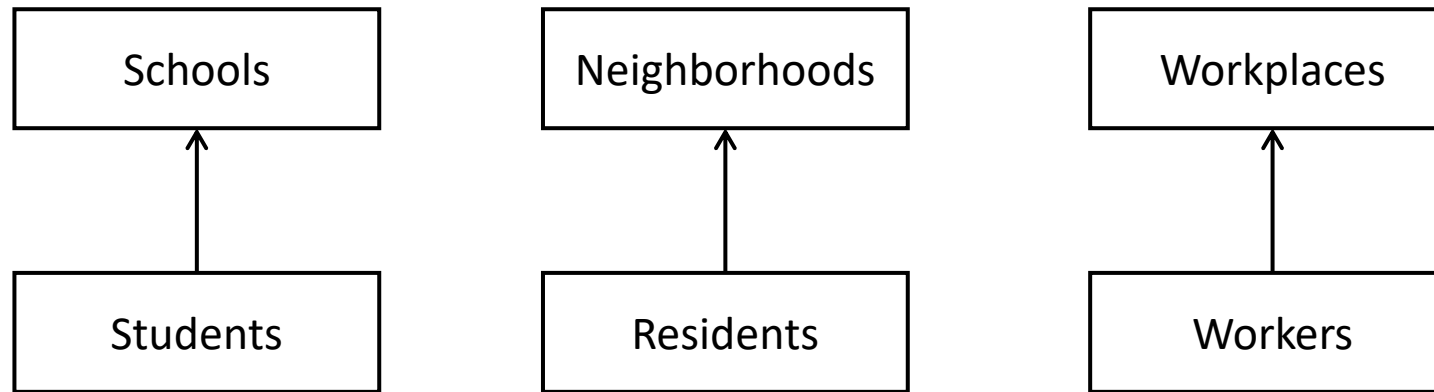
Using Multilevel Models for Intersectional Inequities Research (MAIHDA)

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University of Bristol

13 July 2026

Familiar uses of Multilevel Models ...



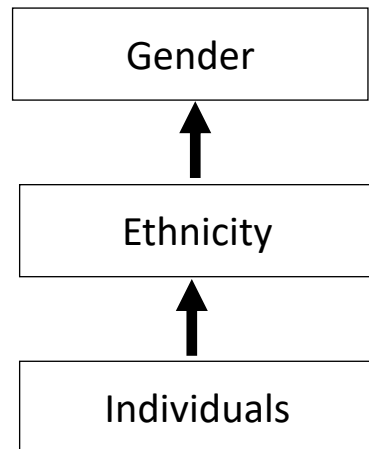
Familiar Rationale ...

- Shared environments lead to **correlated outcomes**.
- Environments are often **conceptualized as 'concrete'** – e.g., built environments, social environments.
- Multilevel modeling allows us to evaluate **variation** *within* and *between* clusters, as well as **average differences**.

Level or Variable?

Example	Level or Variable?
Socioeconomic Status	
Race / Ethnicity	
School Type (public, private)	
States	
Neighborhoods	
Parents	
Age	
Observation Occasions	

Conventional
Wisdom:
We **cannot** treat
Variables as Levels.



Can Levels be treated as Variables?

YES:

Example: schools are included as “dummy variables” in the fixed part of the regression model.

- Inferring things about *specific* schools.
- “Removing” the “school effect.”

However: If schools are treated as a level ...

- Then we are thinking about a “population” of schools.
- Schools are of interest.
- Inequalities *between* schools.
- Differences/inequalities *within* schools.

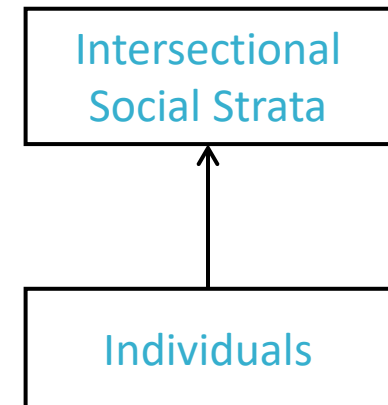
Big ideas today –

We can **do a better job** of **estimating inequalities**.

Multilevel models can be applied to more **abstract** types of clustering.

Unfamiliar uses of Multilevel Models ...

Intersectional Inequities
High-Dimensional Interactions



Intersectionality – early origins

Combahee River Collective Statement – 1970s Black lesbian feminist and socialist activists

The group chose the name “Combahee River” to honor the American abolitionist and social activist, [Harriet Tubman](#).

On [2 June 1863](#), Tubman became the first woman to lead a major military operation in the U.S. when she led a raid up the Combahee River in South Carolina and [emancipated >750 enslaved Black people](#).



Harriet Tubman, circa 1868/1869.



Top (left to right): Margo Okazawa-Rey, Barbara Smith, Beverly Smith, Chirlane McCray, and Mercedes Tompkins.
Bottom (left to right): Demita Frazier and Helen Stewart.

Intersectionality – early origins

Combahee River Collective Statement – 1970s Black lesbian feminist and socialist activists

“We ... find it difficult to separate race from class from sex oppression because in our lives they are most often **experienced simultaneously**.”

“... we are actively committed to struggling against racial, sexual, heterosexual, and class oppression, and see as our particular task the development of **integrated analysis and practice** based upon the fact that **the major systems of oppression are interlocking**.”

The synthesis of these oppressions creates the conditions of our lives.”

Not a general theory of identity.

Part of **a long and on-going struggle against oppression**, requiring activism, community-building and consideration of collective needs.



*Top (left to right): Margo Okazawa-Rey, Barbara Smith, Beverly Smith, Chirlane McCray, and Mercedes Tompkins.
Bottom (left to right): Demita Frazier and Helen Stewart.*

Intersectionality

Black Feminist scholarship

(Collins 1990; Crenshaw 1989)



Dr. Kimberlé Crenshaw



Dr. Patricia Hill Collins



Intersectionality

Black Feminist scholarship

(Collins 1990; Crenshaw 1989)

A *critical* theory and analysis framework

- Inequities are generated by *interlocking* systems of privilege and oppression.
- Center the experiences of the *marginalized*.
- Consider *many axes* of marginalization.
- Challenge systems and institutions – *transformative* aims.

A *unifying* framework – built a *coalition of critical theories*



Intersectionality

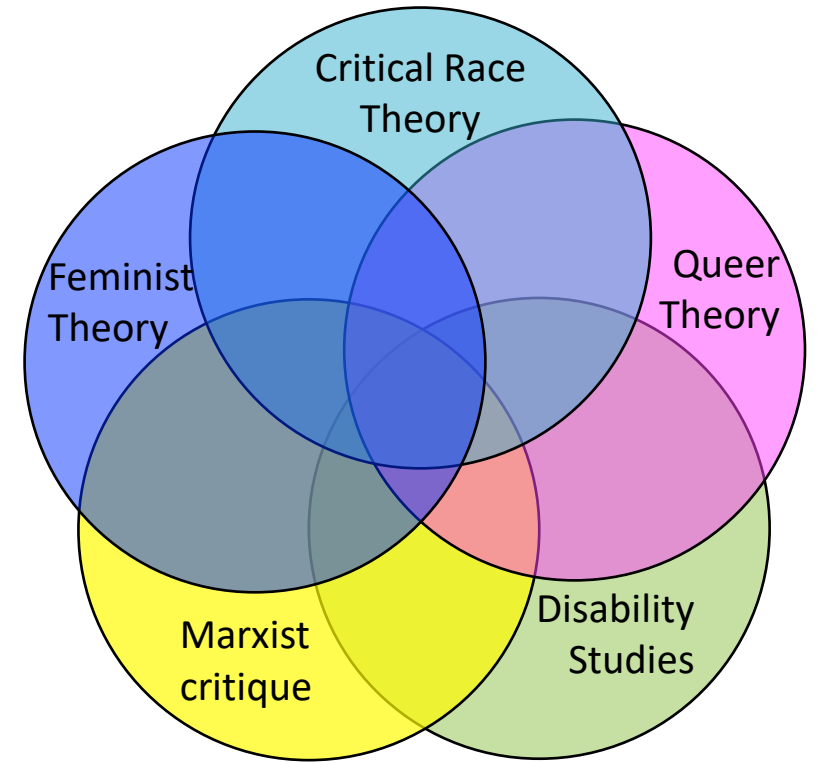
Black Feminist scholarship

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A *critical* theory and analysis framework

- Inequities are generated by *interlocking* systems of privilege and oppression.
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Intersectionality

Common Approaches in Research

(McCall 2005)

Anticategorical

Deconstructs analytical categories.

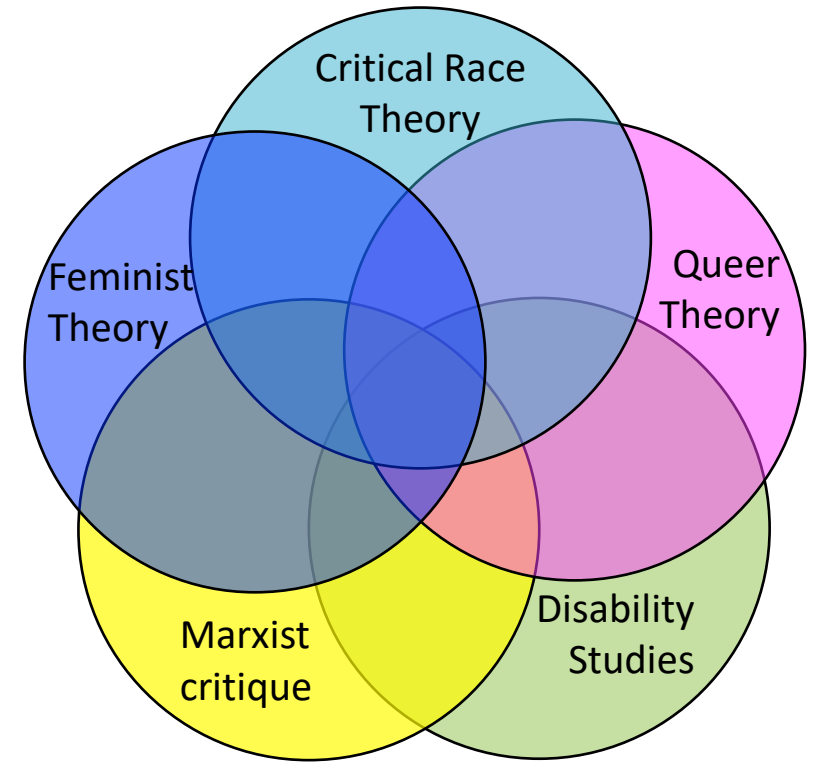
Intracategorical

Focus on particular (often neglected) intersections.

Intercategorical

Provisionally adopt use of categories/labels in order to quantify inequities.

- Often the approach taken in quantitative research.
- Categorizations of identity/status are **proxies for social experiences**.
- **Rejection of “additive approach”**: Black woman $\neq$ Black + woman



(1) Why is public health interested in high-dimensional interactions? intersectionality?

Theories of population health and health inequality –

- Fundamental Causes of Health Inequality (Link & Phelan 1995).
- Social Production/Political Economy (Doyal 1979; Conrad & Kern 1981).
- Ecosocial Theory (Krieger 1994; 2011).

→ **Theme:** pay attention to multiple axes of marginalization and socioeconomic inequity.

Similar themes in other fields –

- Social sciences
- Health and medical sciences, social work, education
- Environmental sciences/environmental justice

Intersectionality (Collins 1990; Crenshaw 1989)

- Increasingly applied to theorize inequities.

(2) Why a new approach? - Challenges and Motivation

Fixed Effects approach

$$Y_i = \beta_0 + \beta_1(\text{woman}_i) + \beta_2(\text{Black}_i) + \beta_3(\text{woman}_i \times \text{Black}_i) + e_{0i}$$

Theory-based Critiques

1. Unintentionally reinforces the **social primacy** of the multiply privileged.
2. Tendency to revert to **single-axis thinking**.
3. What about interaction effects for **other social strata**?

Methodological Limitations

1. As number predictors ↑, number of interaction terms ↑
geometrically – **difficulty with scalability and model parsimony**.
2. Small sample size at many intersections – **unstable estimates**.
3. “**Tyranny of the averages**” problem – focus on averages, less attention on variances.
4. Can be **difficult to interpret results**.

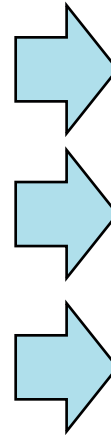


The Intersectional Insight that inspired Intersectional MAIHDA



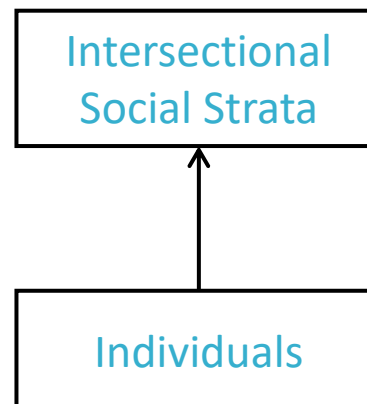
Familiar Rationale ...

- **Environments** are often **conceptualized** as 'concrete'.
- **Shared environments** lead to **correlated outcomes**.
- Multilevel modeling allows us to evaluate **variation within** and *between* clusters, as well as **average differences**.



Unfamiliar uses ...

- **Positionalities** within interlocking systems of oppression are **a type of environment**.
- **Shared positionalities** leads to **correlated outcomes**.
- We want to think about **variation within** and *between* social groups, as well as **average differences**, when we evaluate inequalities.



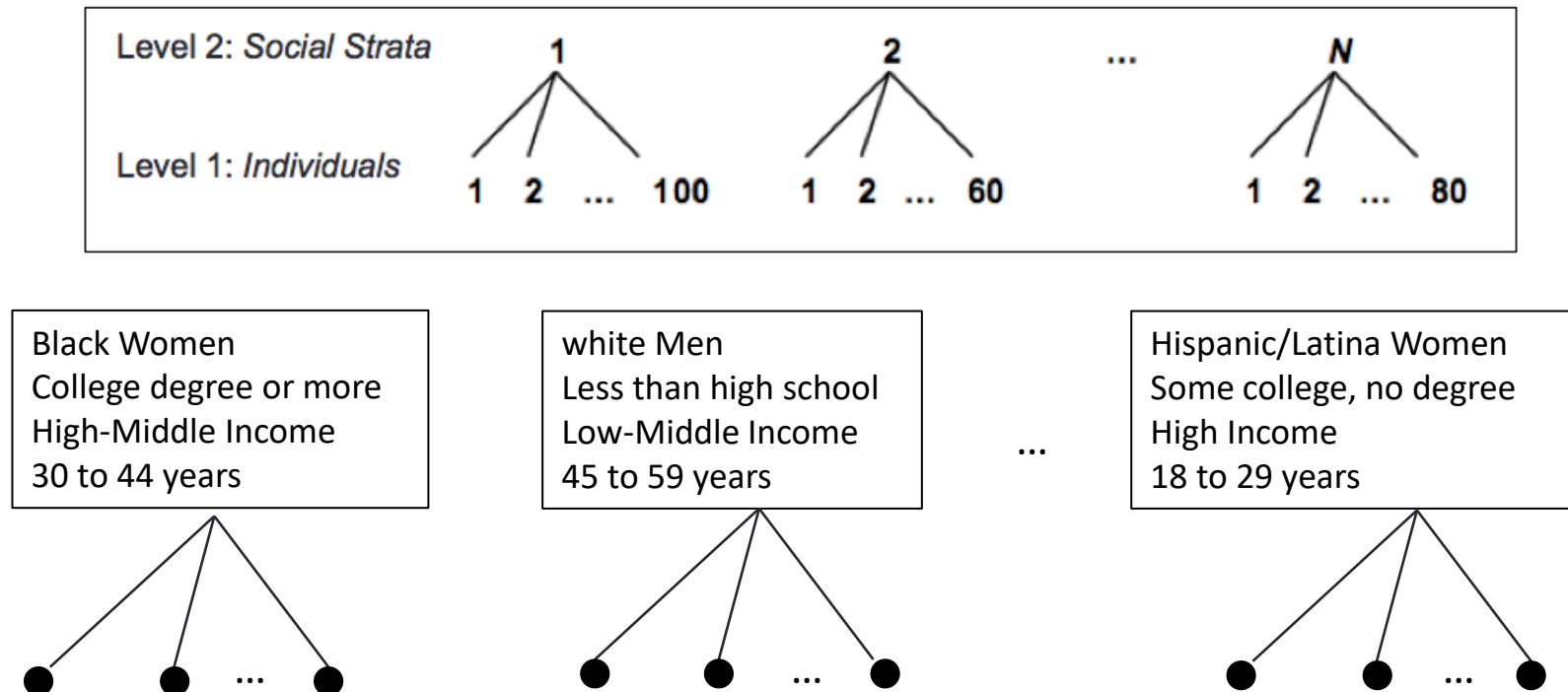
Multilevel models fit well with intersectional theorizing.

Can they help to address the limitations of conventional approaches?

(3) What is (Intersectional) MAIHDA and how does it work?

Intersectional MAIHDA

Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy



Partitioning the Variance – only 4 social strata

Fixed Effects approach – single-level model:

$$y_i = \beta_0 + \beta_1(woman_i) + \beta_2(Black_i) + \beta_3(woman_i \times Black_i) + e_i$$

MAIHDA approach

Model 1 – Null Model:

$$y_{ij} = \beta_0 + \mu_j + e_{ij}$$

μ_j = total stratum-level residual for stratum j .

Model 2 – Additive Main Effects Model:

$$y_{ij} = \beta_0 + \beta_1(woman_j) + \beta_2(Black_j) + \mu_j + e_{ij}$$

μ_j = stratum-level residual $\approx$ interaction effect* for stratum j .

* Estimated for all strata.

Random Effects

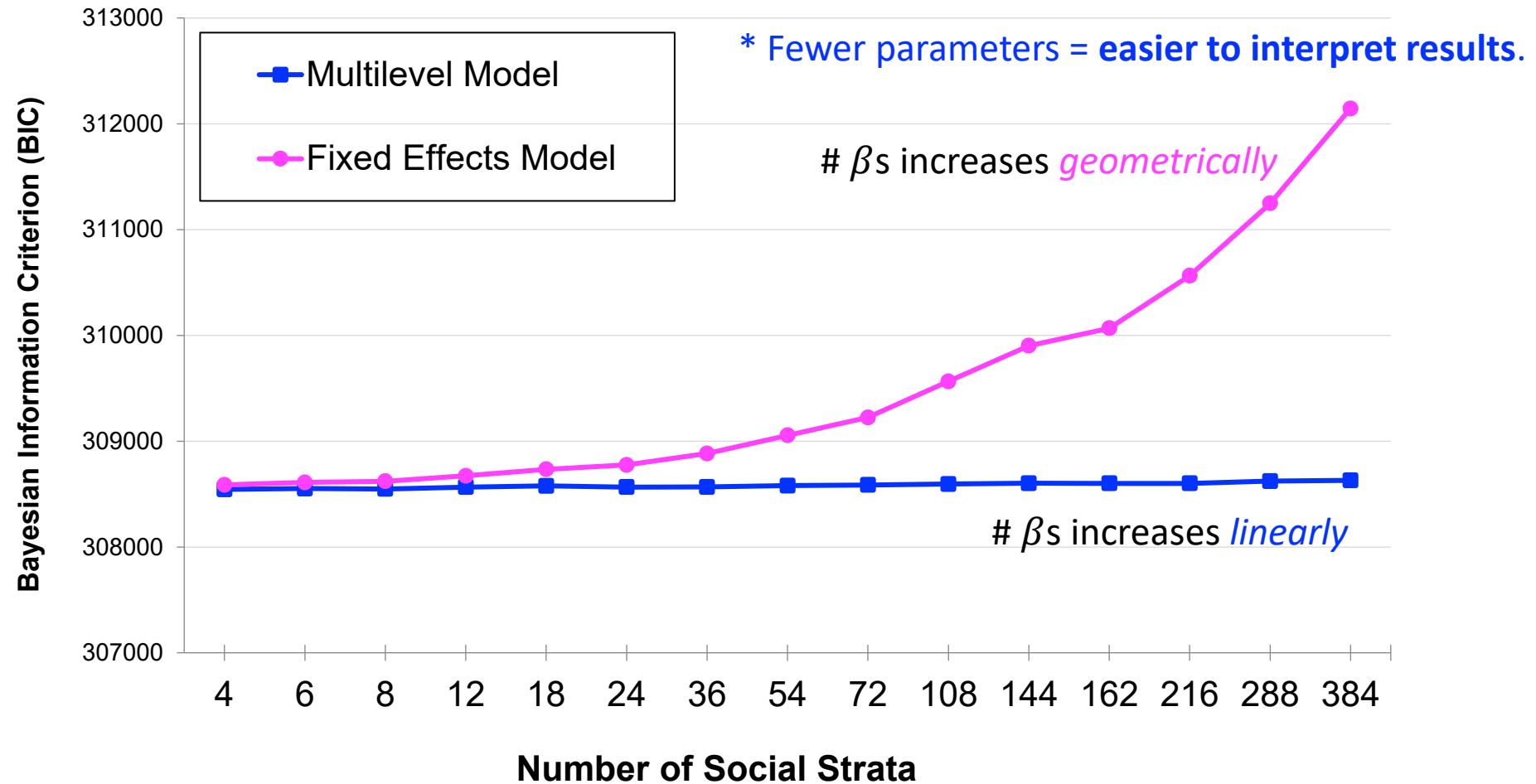
$$[\mu_j] \sim N(0, \sigma_u^2) \text{ Between-Stratum Variance} = \sigma_u^2$$

$$[e_{ij}] \sim N(0, \sigma_e^2) \text{ Within-Stratum Variance} = \sigma_e^2$$

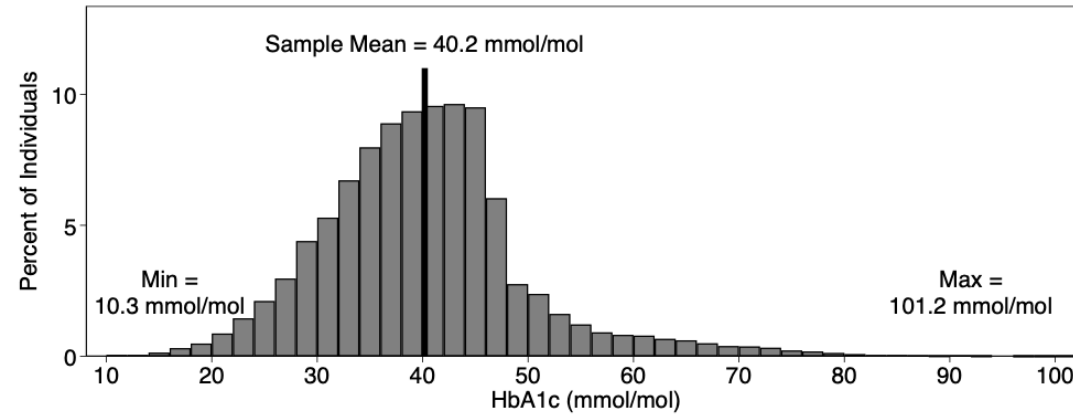
Why a new approach?

Simulation Results

* Multilevel approach provides greater **scalability** due to improved model **parsimony**.

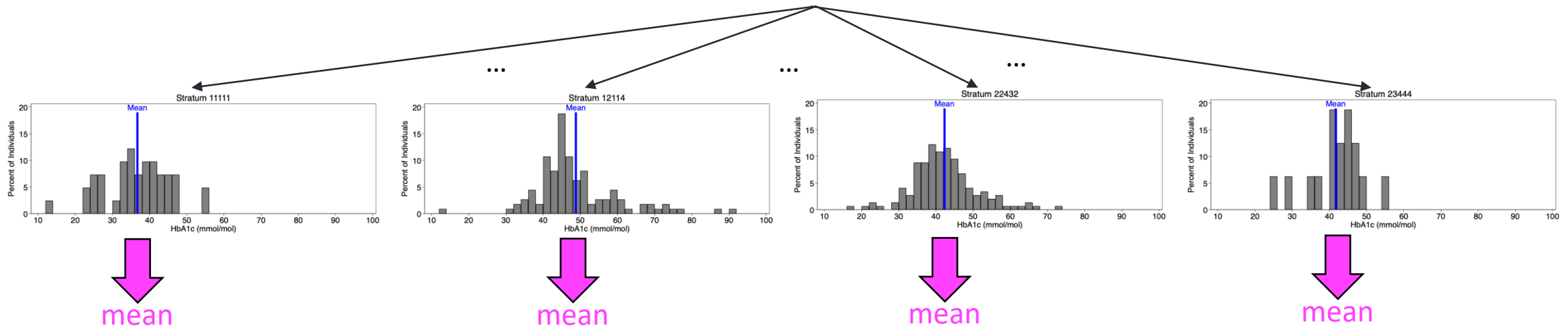
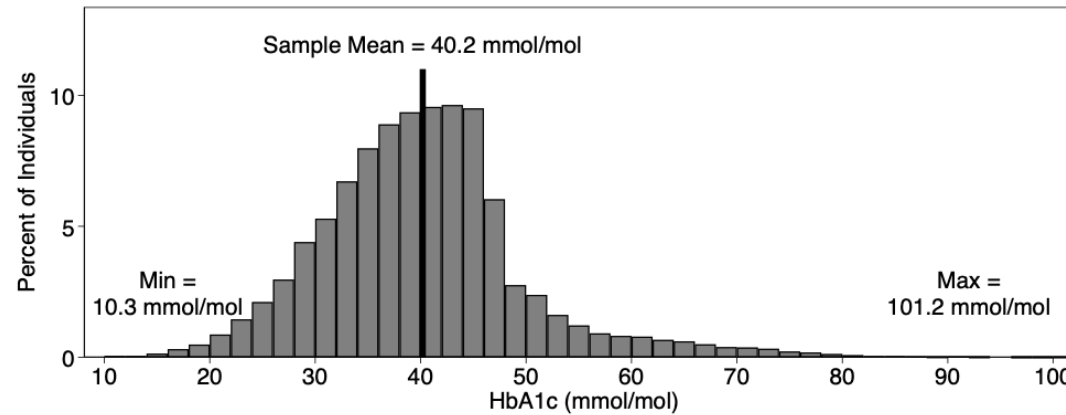


Visualizing the Data



Fixed Effects – a fancy way to calculate the average in each stratum?

“Simple Means” Family of approaches.

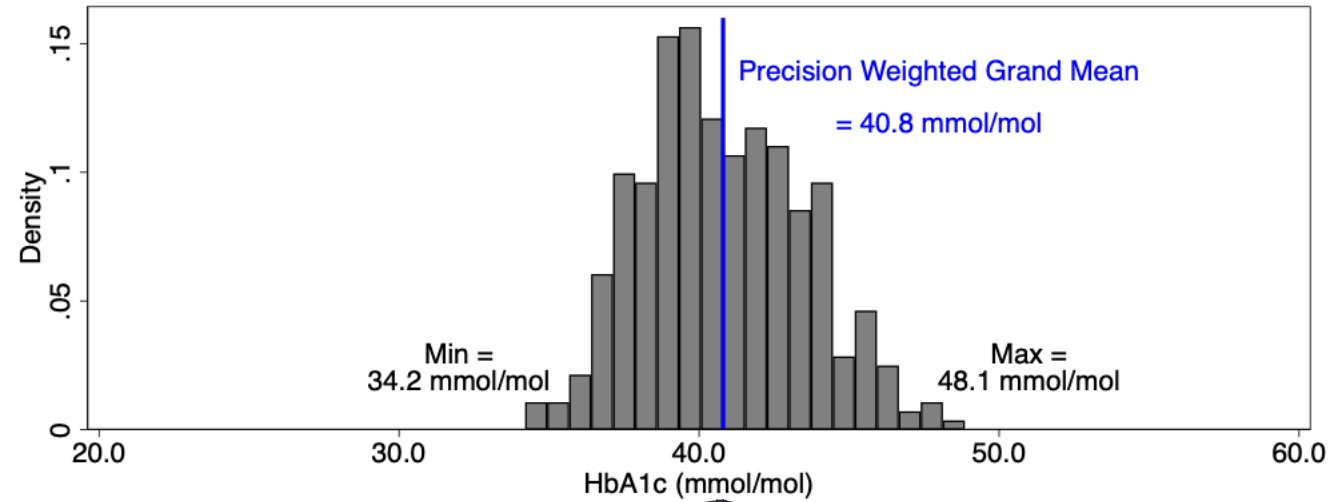


Fixed Effects approach (single-level model)

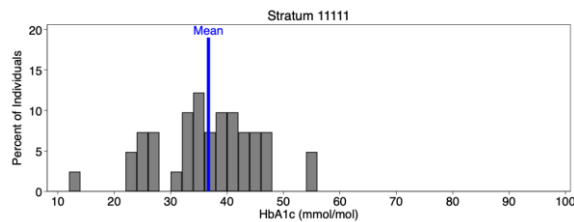
$$E[y_i | x_{1i}, x_{2i}, \dots] = \beta_0 + \beta_1(x_{1i}) + \beta_2(x_{2i}) + \beta_3(x_{1i})(x_{2i}) + \dots$$

Multilevel Thinking

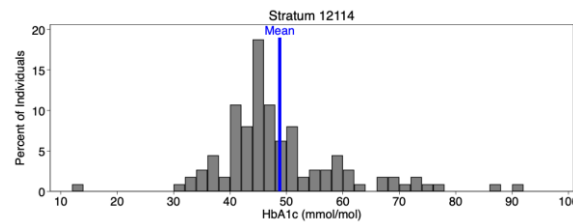
Between-Stratum Variance



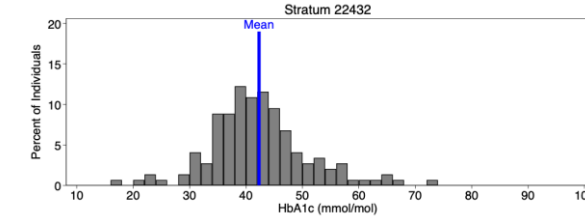
* Multilevel approach considers variation as well as averages.
→ overcome the “tyranny of the averages” problem.



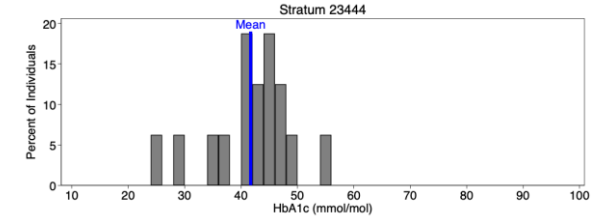
Within-Stratum Variance



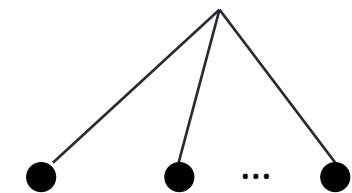
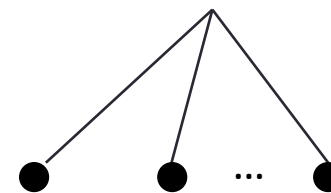
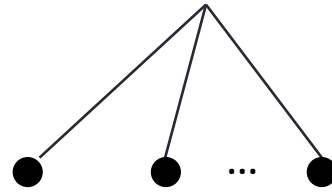
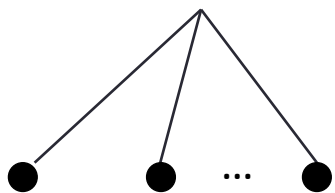
Within-Stratum Variance



Within-Stratum Variance

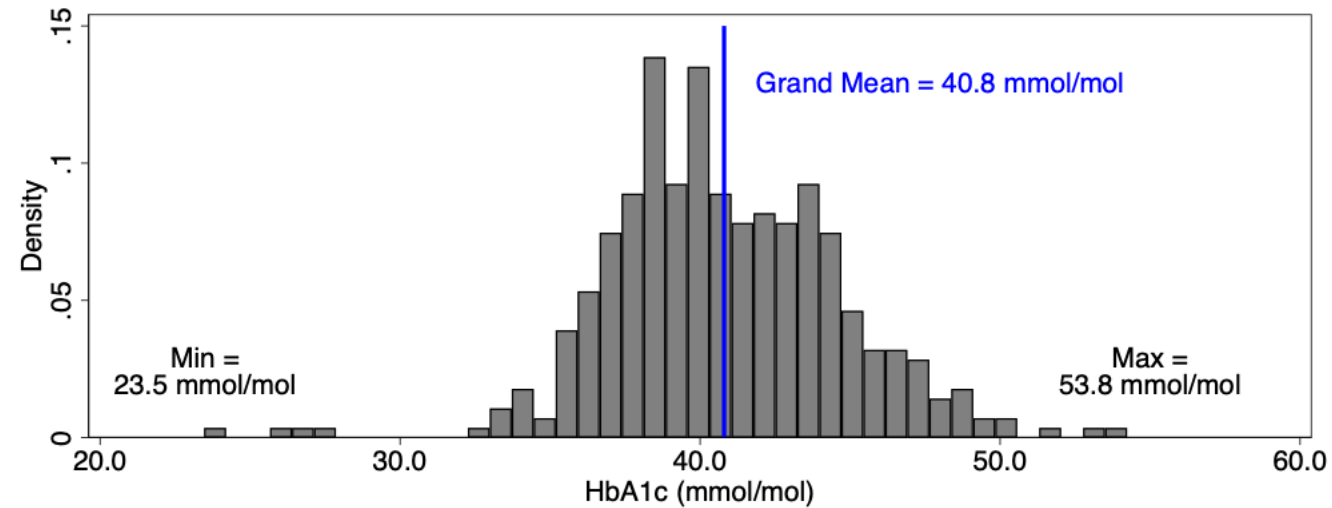


Within-Stratum Variance

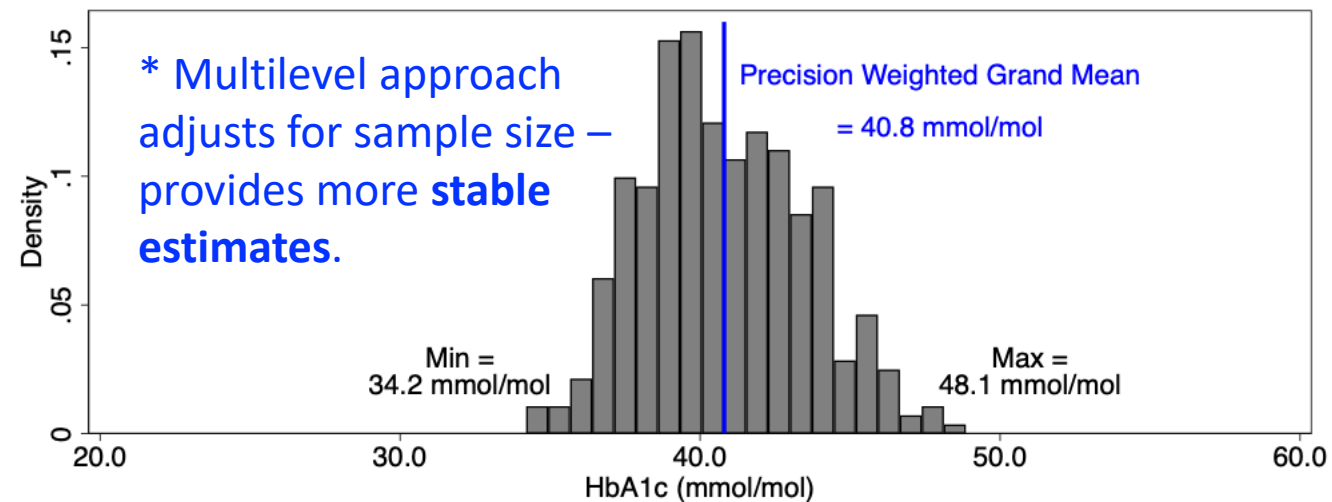


Precision Weighting in MAIHDA

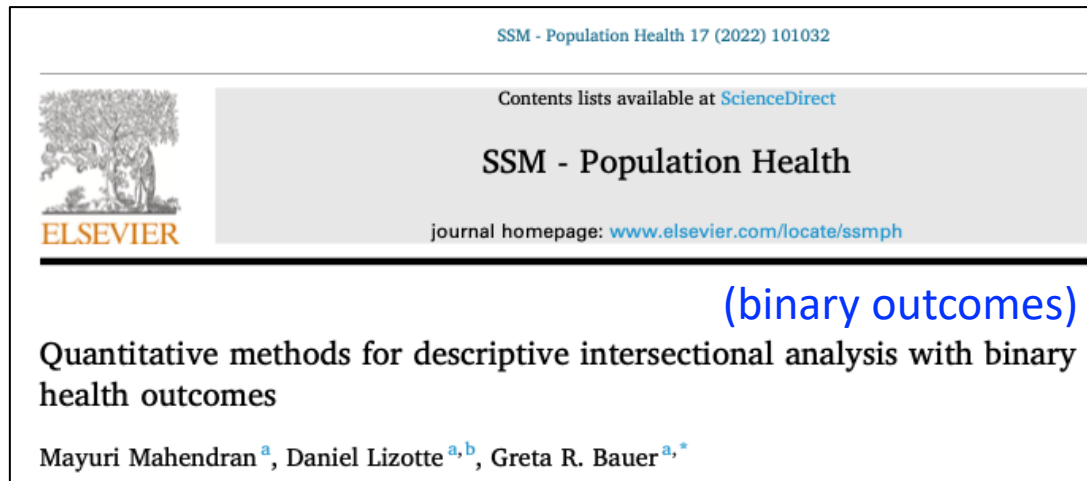
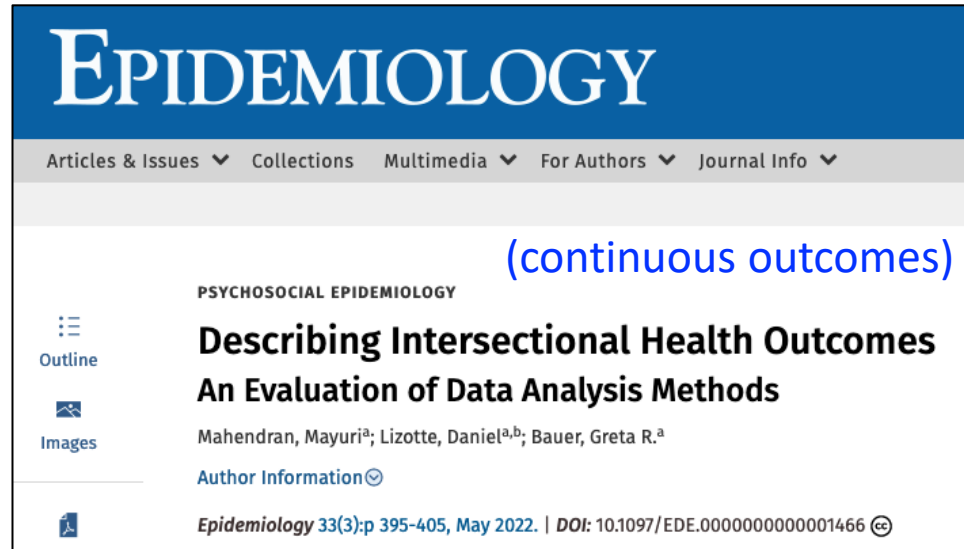
Fixed Effects Model



MAIHDA Model



Comparing methods...



Simulation studies systematically comparing MAIHDA with other approaches:

- cross-classification
- single-level regression with interactions
- decision-tree methods
 - classification and regression trees [CART]
 - conditional inference trees [CTree]
 - random forest
 - chi-square automatic interaction detector [CHAID]

MAIHDA is the preferred method, especially for high-dimensional intersections and when sample sizes are small.

MAIHDA approach to modeling high-dimensional interactions addresses...

Theoretical Critiques

1. No reference strata specified *a priori* – **does not reinforce primacy of multiply privileged.**
2. Easier to **remain intersectional.**
3. Intersectional **interaction effects estimated for all strata.**

Methodological Limitations

1. As dimensions of identity ↑, additive fixed effect parameters ↑ *linearly* rather than geometrically – **improved scalability and model parsimony.**
2. Adjusts for sample size of strata – **improved estimate stability.**
3. Considers averages and variance around averages – **avoids “tyranny of the averages”** problem.
4. Easier to **summarize and interpret** findings.

Examples of Applications

Rx Opioid Misuse

understanding the patterning of misuse inequities, intersectionally

2015 National Survey on Drug Use and Health (NSDUH-2015)

cross-sectional survey

representative of U.S. non-institutionalized population, age 18+ years

Analyzed Sample:

$N = 43,409$

Note: this is a logistic MAIHDA model.

Generating predicted probabilities for each stratum.

Dependent Variable: past-year prescription opioid misuse (1=yes, 0=no)

Intersectional Strata (72 strata)

<u>Sex</u>	<u>Race/Ethnicity</u>	<u>Income</u>	<u>Age</u>
1 – Male	1 – Hispanic	1 – Low (<200% FPL)	1 – 18 to 29 years
2 – Female	2 – Black	2 – Medium (200-399% FPL)	2 – 30 to 49 years
	3 – White	3 – High (400%+ FPL)	3 – 50+ years
	4 – Other		

Rx Opioid Misuse

What we expect:

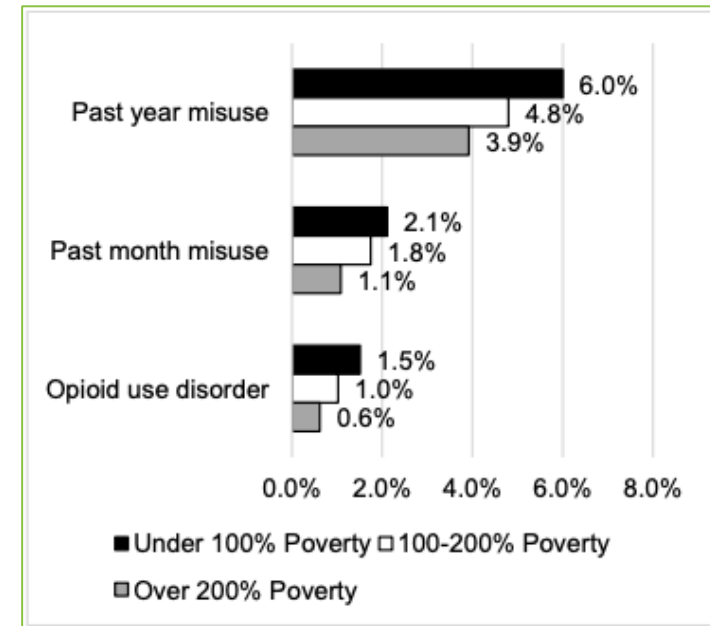
middle-age and older
white
men
low/middle income

Prescription Opioid Overdose Deaths in 2016

Population	Rate per 100,000
White	7.0
Black	3.3
Hispanic	2.1
American Indian/Alaska Native	6.5
Asian/Pacific Islander	0.7

Population	Rate per 100,000
ALL	5.2
Male (all ages)	6.2
15-24 years	3.8
25-44 years	10.6
45-64 years	10.0
Female (all ages)	4.3
15-24 years	1.4
25-44 years	6.2
45-64 years	8.5

Past Year Opioid Misuse by Poverty Status, 2016



Source: 2016 National Survey on Drug Use and Health

Source:
CDC Morbidity and
Mortality Weekly Report
30 Mar 2018

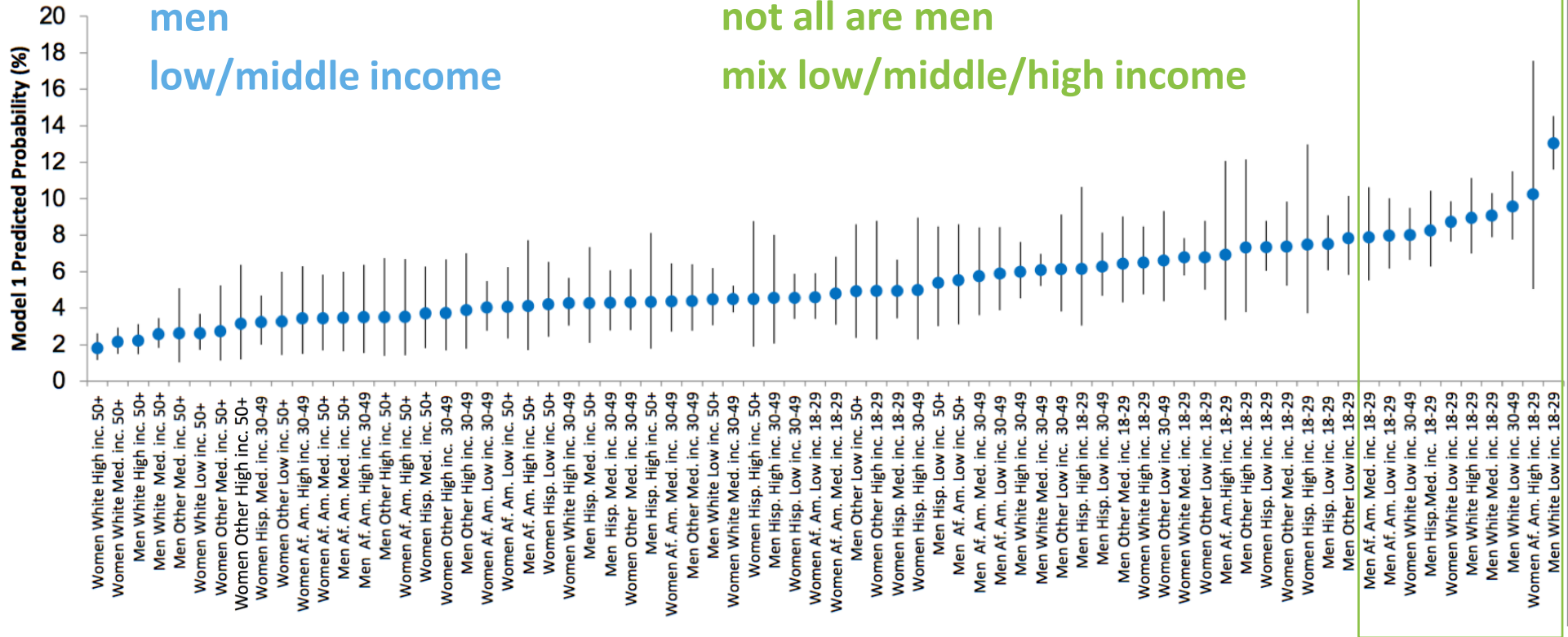
Rx Opioid Misuse

What we expect:

middle-age and older
white
men
low/middle income

What we find:

younger
not all are white
not all are men
mix low/middle/high income



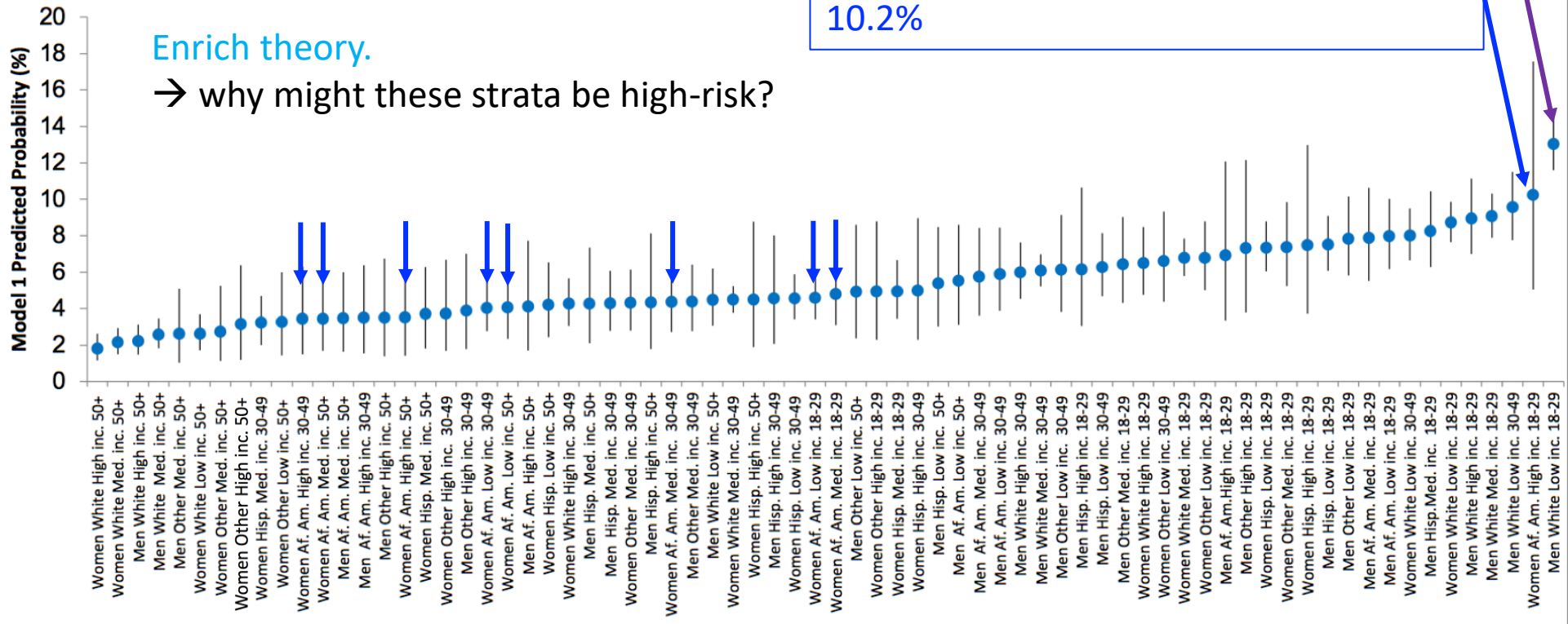
Rx Opioid Misuse

Challenge our understanding / reveal unseen realities.

→ are there high-risk strata we didn't recognize before?

Enrich theory.

→ why might these strata be high-risk?



(4) How does MAIHDA help us do a better job estimating inequalities?

Analytic Goals –

- Mapping averages / probabilities across strata.
- Quantify heterogeneity (variation) within and between strata.
- Estimate interaction effects.



Broader Aims –

- Expand diversity & inclusion in research.
- Enrich theory. Challenge dominant narratives.
- Reveal unseen realities.
- Identify populations at high risk / in need of resources.
- Quantify inequities (“gaps”).
- Avoid “tyranny of the averages.”
- Recognize heterogeneity / variation.
- Critique power structures and systems of oppression.
- Motivate and support transformation.

Thank You!

