PH784 Advanced Social Epidemiology: Methods

Week 1: Intro & Measures of Helath Disparities

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Structure

- Who am I?
- Course Overview
- Measures of Health Disparities

Who am I?

Social epidemiologist, assistant professor

What I study

1. **Social Determinants of Health**
    i. Social connectedness
    ii. Traumatic experiences
    iii. Positive psychological wellbeing
2. **Causal Inference**

Selected articles. Social connectedness: (Shiba et al. 2021c; Nakagomi et al. 2023); Traumatic experience: (Shiba et al. 2021b,

Past Methodology Work

- Propensity score methods: assumptions and causal estimand
- Outcome-wide study & E-values
- Causal estimand in the presence of selection bias and non-proportional hazard
- Causal effect decomposition for life course epidemiology
- **Machine learning (ML) for causal inference**

Selected articles. Propensity score: (Shiba and Kawahara 2021); Outcome-wide analysis: (Shiba et al. 2022b); Selection bias & non-

Social Epidemiology is Hard

We provide scientific evidence on:

1. Health disparities (descriptive)
2. Social determinants of health (causal)

This is hard because what we study are:

- Invisible, multi-dimensonal
- Complex
- Hard to manipulate
- Dynamic
    - → Change across time, space, and populations
- Distributional

Methods in Social Epidemiology



- **Both are critical**
  - → Trends in population data & depths
  - → Theories shape questions, interpretation, methodology, reporting [1]
- This course will focus on **quantitative methods**
  - → Not so much about statistical methods
  - → More on interpretation, assumptions, applications
    - In the context of social epi

Course Overview

Topics to be covered

Week	Topic	Description
1	Descriptive	Measures of health disparity
2-3	Causal Inference	How to analyze data
4	Measurement	How to measure social constructs
5	Estimand	Questions
6-7	Interaction & Mediation	Applications in social epi

Goal

- NOT to teach you every single detail
- NOT to be prescriptive
- To provide big-picture overviews of key thinking and debates
  - → But with some equations
  - → So you can learn more from the literature

Evaluation

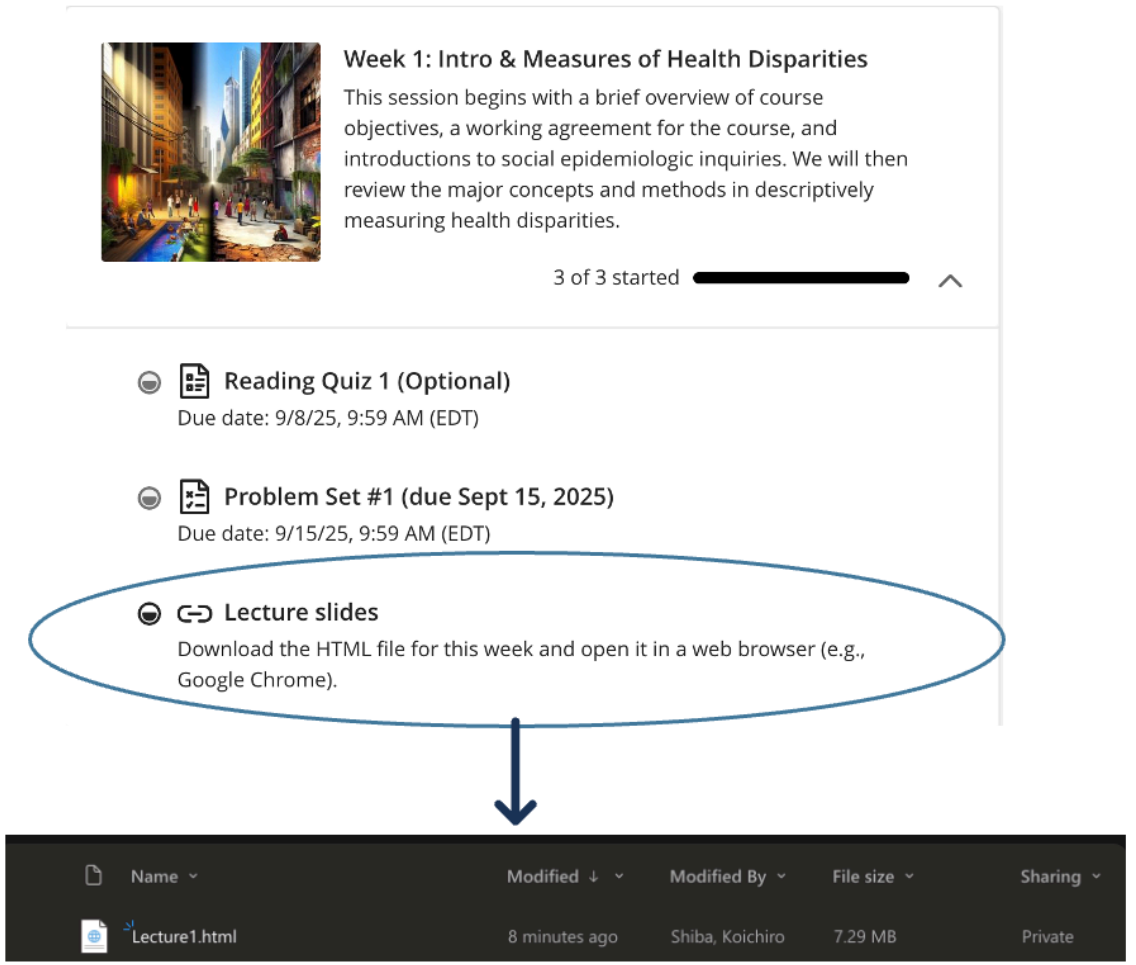
Assessment	% Grade
Class Participation	10%
Weekly Reading Quiz	10%
Weekly Problem Set	60%
Final Paper	20%
Total	**100%**

- Class participation
  - → In-class discussion
- Problem set
  - → Data analysis in R
    - Use sample codes
    - Questions to the TA (Shivani Pande: sp2804@bu.edu)

> ⓘ **Prioritize learning rather than grading**

Lecture slides

- HTML file created using `Quarto`
  - → Reproducibility
  - → Embedded code
- How to use
  1. Go to the shared folder
  2. Download the html file
  3. Open it in a web browser (e.g., Google Chrome)



Descriptive Epidemiology

- A snapshot of a real-world distribution
  - → Of Diseases (e.g., mortality), risk factors (e.g., smoking), etc
  - → Comparisons across population, space, time
- Measure disease burden/frequency
  - → mean, risk, prevalence, rate
- **Motivation?**
  - → Identify problems
  - → Assess performance
  - → Monitor progress

Example

World Well-being Ranking

Country	Mean
New Zealand	7.71 (1)
Ireland	7.67 (2)
Australia	7.59 (3)
Canada	7.59 (4)
Uzbekistan	7.58 (5)
Iceland	7.55 (6)
Norway	7.52 (7)
United States	7.50 (8)
Netherlands	7.50 (9)
Indonesia	7.50 (10)

- Data from the Gallup World Poll (Shiba et al. 2022a)
  - → 1.2 million individuals across 162 countries
- Top 10 countries with the “highest level of well-being”
  - → Ranking based on country-specific average scores
    - What is missing?

What about within-population distributions?

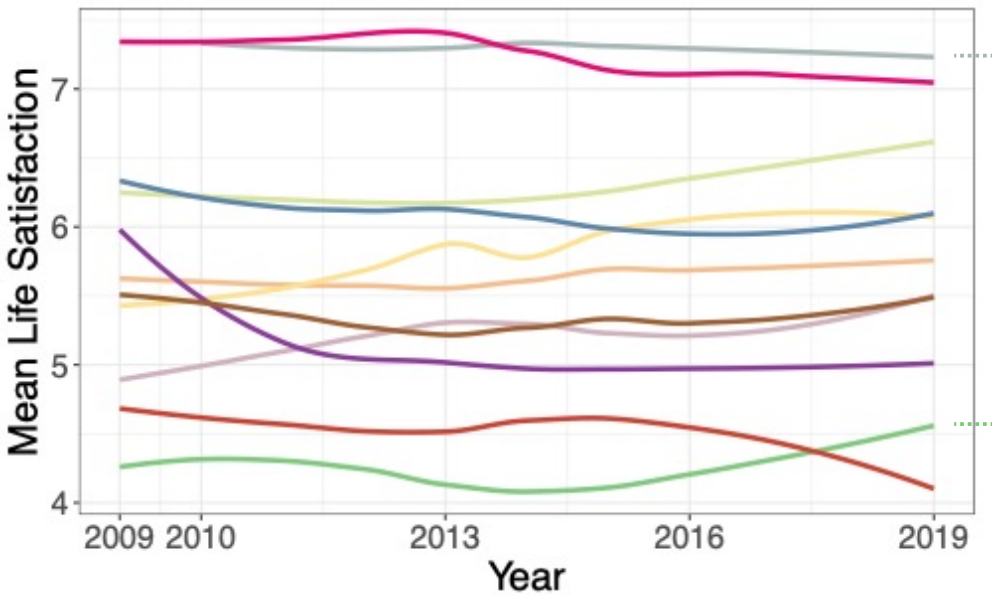
Example

World Well-being "Equality" Ranking

Country	Mean	Equality
New Zealand	7.71 (1)	0.094 (4)
Ireland	7.67 (2)	0.096 (6)
Australia	7.59 (3)	0.100 (15)
Canada	7.59 (4)	0.099 (14)
Uzbekistan	7.58 (5)	0.097 (10)
Iceland	7.55 (6)	0.090 (2)
Norway	7.52 (7)	0.096 (7)
United States	7.50 (8)	0.107 (29)
Netherlands	7.50 (9)	0.097 (12)
Indonesia	7.50 (10)	0.098 (13)

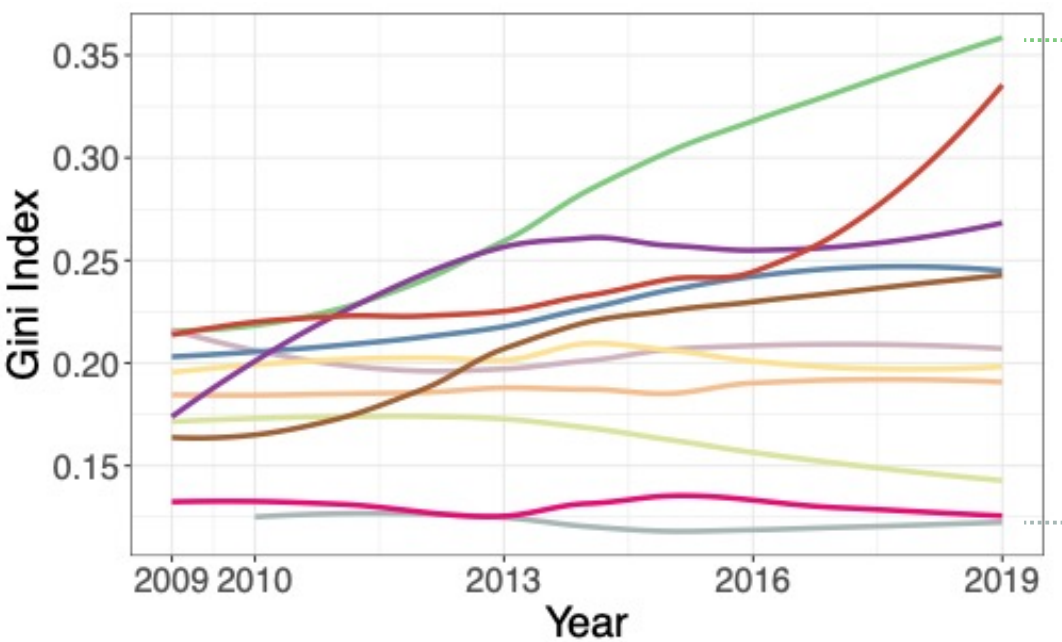
- Going beyond the "mean" ranking
  - → Equality of the well-being measure
  - → Assessed with the Gini index
- Different ranking for the degree of equality
  - → e.g. United States
    - Relatively high average well-being (8th) but low equality (29th)

Example



Australia-New Zealand

Africa (Sub-Saharan)



Africa (Sub-Saharan)

Australia-New Zealand

Within-Population Distribution of Health

Average is not the only way to summarize population health

- **Total inequality**
  - → Measures: SD, Gini Index
    - Often not reported but can be informative
    - Without introducing ethical values (more on this later)
- **Social group inequality**
  - → Disproportionate health distributions across social groups
    - “Health disparities”

Terminology

- **Health disparity**
  - → Common in the United States
- **Health inequality**
  - → More often used internationally

> "Health disparities/inequalities are potentially avoidable differences in health (or in health risks that policy can influence) between groups of people who are more and less advantaged socially; these differences systematically place socially disadvantaged groups at further disadvantage on health" (Braveman 2006)

! Underlying Values?

Values in Health Disparity/Inequality

- **Who are socially disadvantaged/advantaged?**
  - → often, race and ethnicity, socioeconomic status
  - → gender, sexual orientation, disability
  - → anything else?
- **Health differences in favor of the disadvantaged group?**
  - → e.g., higher suicide rates among white men
    - Is this not inequality?
  - → Judgement about equity

⚠Things to avoid

- Publication bias (“Not worth reporting”)
- Confirmation bias (“This cannot be right”)

Health Inequity

Health differences that are considered unfair and unjust

- Health disparity: $E[Y|SES = high] - E[Y|SES = low]$
  - → Is this inquity?
    - Requires value judgements

Distinguish disparity/inequality from inequity

- Use the term “disparity” when referring to statistical findings
  - → How do we explicitly incorporate equity values in statistical analyses?
    - “Allowable” covariates (Jackson 2021)

Summary 1

- Go beyond averages when summarizing population health
- Total inequality
- Social group inequality
  - → Health disparity/inequality
  - → Health equity
    - Be mindful of underlying value judgements

How do we quantify health disparity/inequality?

- Defined as social group inequalities

Measures of Social Group Inequalities

Pair-wise comparison: the simplest approach

- Social group G: Race and ethnicity (e.g., White: $G = 0$ vs Black: $G = 1$)
- Continuous Outcome Y: BMI

Example

- $E[Y|G = 1] - E[Y|G = 0]$
  - → The difference in mean BMI between white and black
  - → This is equivalent to the "exposure-outcome association"
    - β_1 estimated via univariate regression $E[Y|G] = \beta_0 + \beta_1 G$

Example: Racial Disparity in BMI in NHANES data

▶ Code

Manual pair-wise comparison

```
# A tibble: 5 × 3
  Race1     mean   `4`
  <fct>    <dbl> <dbl>
1 Black     28.1     4
2 Hispanic  26.4     4
3 Mexican   26.5     4
4 White     26.7     4
5 Other     24.4     4
```

- The estimated disparity betwee black and white of: $28.10 - 26.72 = 1.38$

Using regression

```
# A tibble: 5 × 5
  term          estimate std.error statistic  p.value
  <chr>            <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)     26.7      0.0935   286.    0
2 Race1Black       1.38     0.235      5.88  4.30e- 9
3 Race1Hispanic   -0.349    0.316     -1.10  2.70e- 1
4 Race1Mexican    -0.220    0.255     -0.863 3.88e- 1
5 Race1Other      -2.29     0.279     -8.20  2.61e-16
```

- The estimate for `Race1Black`: 1.38

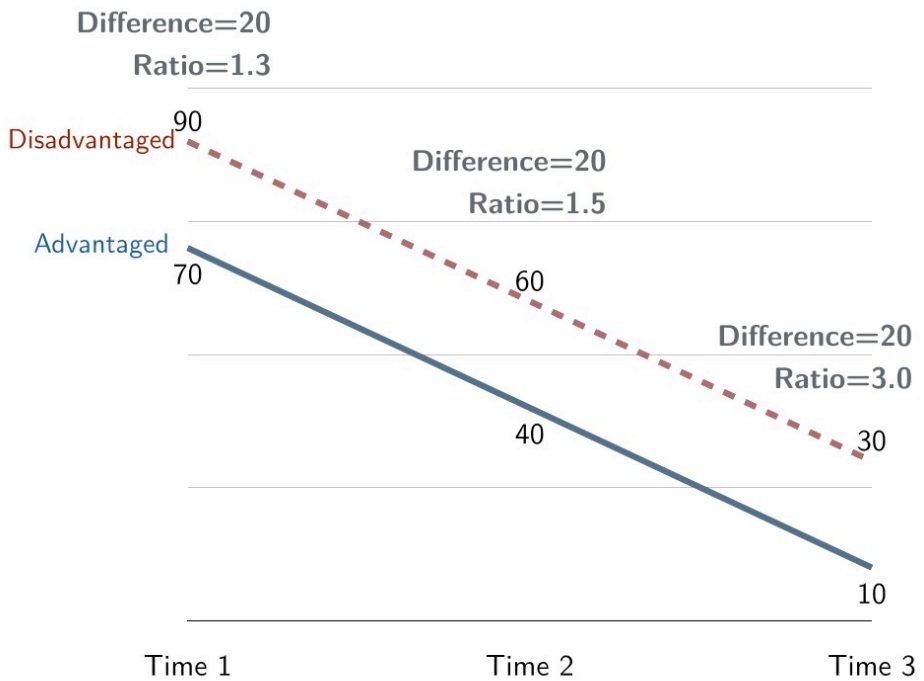
  → Estimated association between black race (vs white) and BMI

Pair-wise Comparison for a Binary Outcome

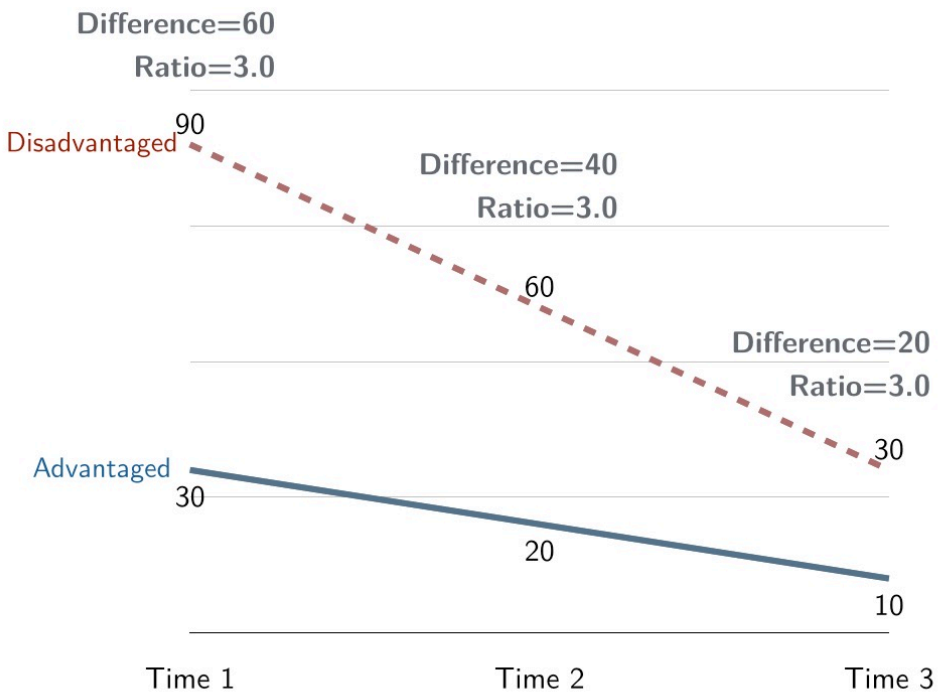
- Social group G: Race and ethnicity (e.g., White: $G = 0$ vs Black: $G = 1$)
- Binary Outcome Y: Depression
  - → Measures of disease frequency
    - Prevalence (snapshot)
    - Risk, rate (onset)
  - → Measures of association
    - Ratio and Difference

> ⓘ **Disparity measures are scale dependent**

Diverging scenarios for absolute and relative inequality trends



- Constant absolute disparity
- Increasing relative disparity



- Decreasing absolute disparity
- Constant relative disparity

Example: Racial Disparity in Diabetes in NHANES data

▶ Code

Manual pair-wise comparison

```
# A tibble: 5 × 2
  Race1      prop
  <fct>     <dbl>
1 Black    0.111
2 Hispanic 0.0781
3 Mexican  0.0666
4 White    0.0715
5 Other    0.0834
```

- The estimated absolute disparity: $0.111 - 0.0715 = 0.0395$
- The estimated relative disparity: $\frac{0.111}{0.0715} = 1.55$

Using linear regression

```
# A tibble: 5 × 5
  term          estimate std.error statistic  p.value
  <chr>            <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)    0.0715    0.00336    21.3   2.20e-98
2 Race1Black     0.0391    0.00844     4.63  3.68e- 6
3 Race1Hispanic  0.00653   0.0114      0.574 5.66e- 1
4 Race1Mexican  -0.00494   0.00911    -0.543 5.87e- 1
5 Race1Other     0.0119    0.0101      1.18  2.37e- 1
```

- The estimate for `Race1Black`: 0.039
  - → Linear regression
  - → Estimated prevalence difference
    - **Absolute disparity**

Example: Racial Disparity in Diabetes in NHANES data

▶ Code

Manual pair-wise comparison

```
# A tibble: 5 × 2
  Race1      prop
  <fct>     <dbl>
1 Black    0.111
2 Hispanic 0.0781
3 Mexican  0.0666
4 White    0.0715
5 Other    0.0834
```

- The estimated absolute disparity: $0.111 - 0.0715 = 0.0395$
- The estimated relative disparity: $\frac{0.111}{0.0715} = 1.55$

Using Poisson regression

```
# A tibble: 5 × 5
  term          estimate std.error statistic   p.value
  <chr>            <dbl>     <dbl>     <dbl>     <dbl>
1 (Intercept)     0.0715    0.0471   -55.9   0
2 Race1Black      1.55      0.0993     4.39  0.0000112
3 Race1Hispanic   1.09      0.153      0.570 0.569
4 Race1Mexican    0.931     0.132     -0.543 0.587
5 Race1Other      1.17      0.132      1.17  0.243
```

- The estimate for `Race1Black`: 1.55
  - → Poisson regression
  - → Estimated prevalence ratio
    - **Relative disparity**

Which scale of inequality is your regressin model estimating?

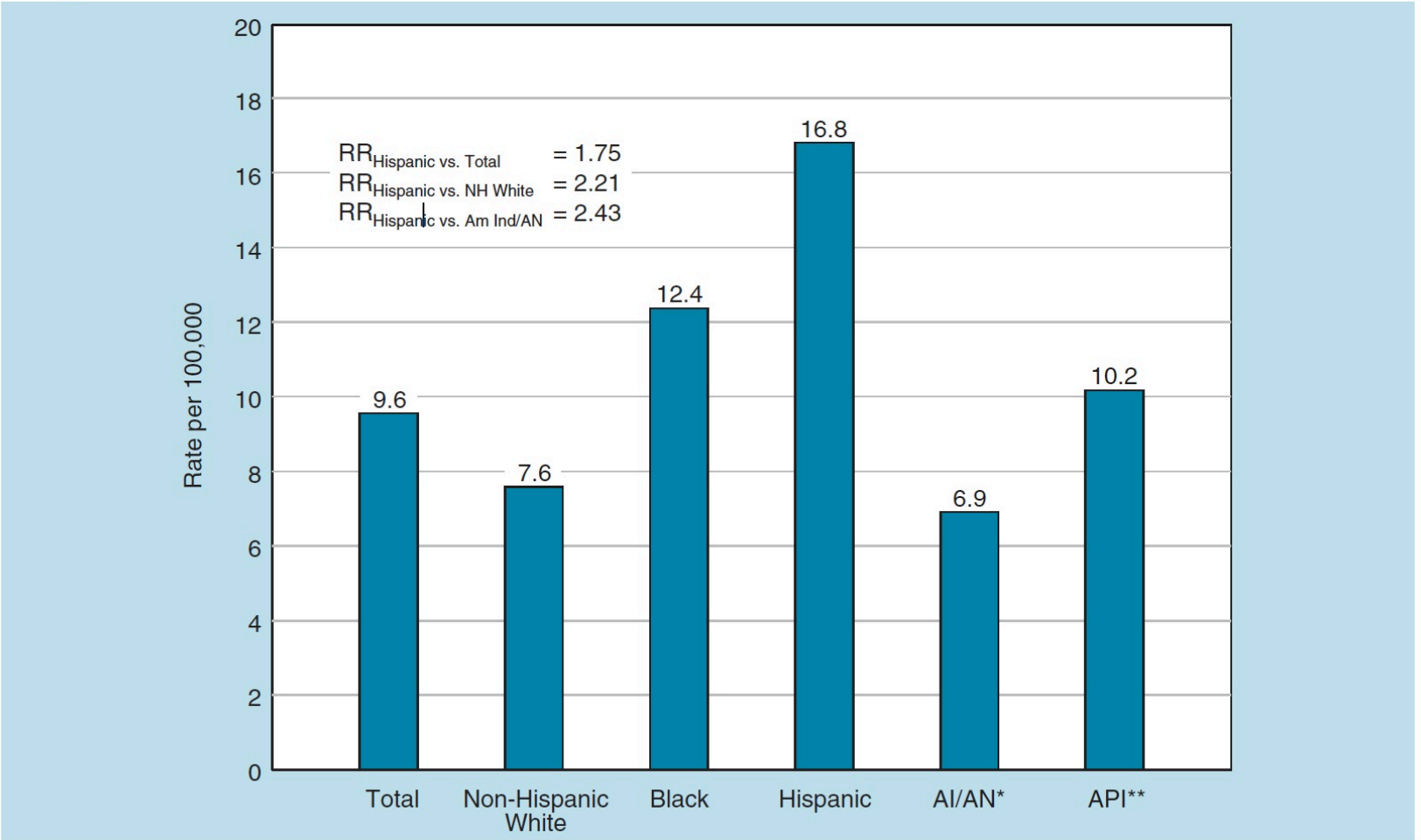
Measures of Social Group Inequalities

Pair-wise comparison: the simplest approach

- Between-group difference via crude regression
- What if we adjust for covariates?
  - → $E[Y|G=1,L]-E[Y|G=0,L]$
    - β_1 estimated via multivariable regression $E[Y|G,L]=\beta_0+\beta_1 G+L\beta$
- Adjusting for “confounders L”?
  - → The “effect of race” on health
    - Debates on the interpretation (Galea and Hernán 2020)
    - We will revisit this issue later in the course
- Non-causal interpretation
  - → “Inequitable disparities” after accounting for allowable covariates (Jackson 2021)

Other Issues to Consider 1: Reference Group

Figure 6. Relative Risk (RR) of Incident Cervical Cancer Among Hispanics According to Varying Reference Groups, 1996–2000

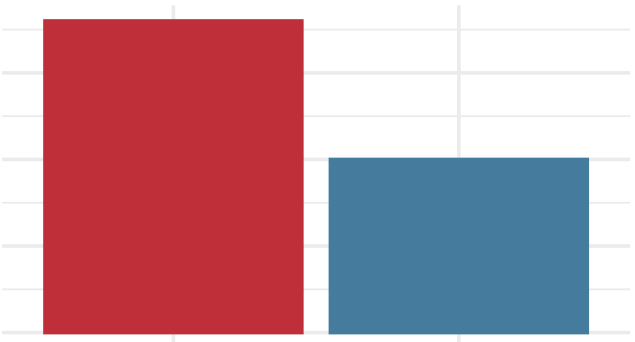


*AI/AN = American Indian/Alaska Native
**API = Asian/Pacific Islander
Source: SEER Cancer Statistics Review, 1975–2000.

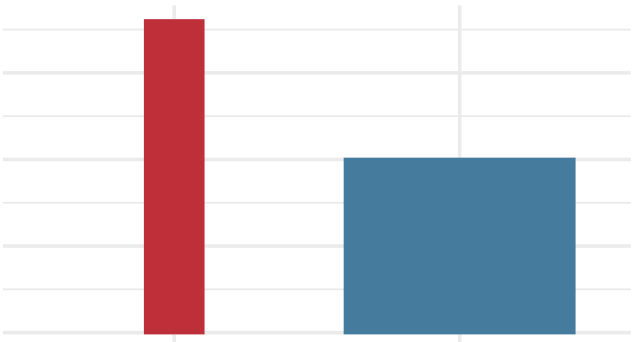
Other Issues to Consider 1: Reference Group

1. **Majority or most socially advantaged group**
    - Involes value judgement
2. **Best-off (healthiest) social group**
    - Unstable if the reference group is small
3. **Population average**
    - Changes over tie

Other Issues to Consider 2: Group Size



Group	Rate	Size
Disadvantaged	90	100
Advantaged	50	100



Group	Rate	Size
Disadvantaged	90	40
Advantaged	50	160

Which is more equitable society?

- Ignore group size?
  - → Smaller weights to the advantaged
- Account for group size?
  - → Can consider changing social group size over time
    - But should we discriminate against a particular group just because it is small?

Summary 2

- Pair-wise comparison as a simple approach to assess social group inequalities
  - → Same as crude associations from univariate regression
- Scales: additive vs relative
  - → Different scales may provide different inequality narratives
  - → Regression for a binary outcome typically reports relative inequalities
    - Report BOTH!
- Reference group and group size adjustment
  - → No right or wrong answer but carefully select your approach

Too many comparisons?

- Reporting all pair-wise comparisons across multiple time points?
- Pair-wise comparisons for income?
  - → Use summary measures to report overall social group inequalities

Summary Measures for Social Inequalities

Averaging social group differences

- **Mean difference from a reference group**
  - → $1/n \times \sum_j |y_j - y_{ref}|$
    - Absolute inequality
    - Which group to choose as y_{ref}?
    - Can be weighted by group size: $\sum_j w_j |\bar{y_j} - y_{ref}|$

- **Relative mean difference (Index of Disparity)**
  - → Divide the absolute measure above by y_{ref}
  - → $\sum_j w_j |\bar{y_j}/y_{ref} - 1|$
    - Relative inequality
    - Varying choices for y_{ref} and w_j across definitions and packages

(!) Always check what choices are made for reference group and weighting

Summary Measures for Social Inequalities

Other metrics

1. Variance measures
2. Disproportionality measures
    - Theil index
3. Regression-based measures for ordered social groups
4. Population impact measures

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

1. Order by SES
2. Regress an outcome on ranking

▶ Code

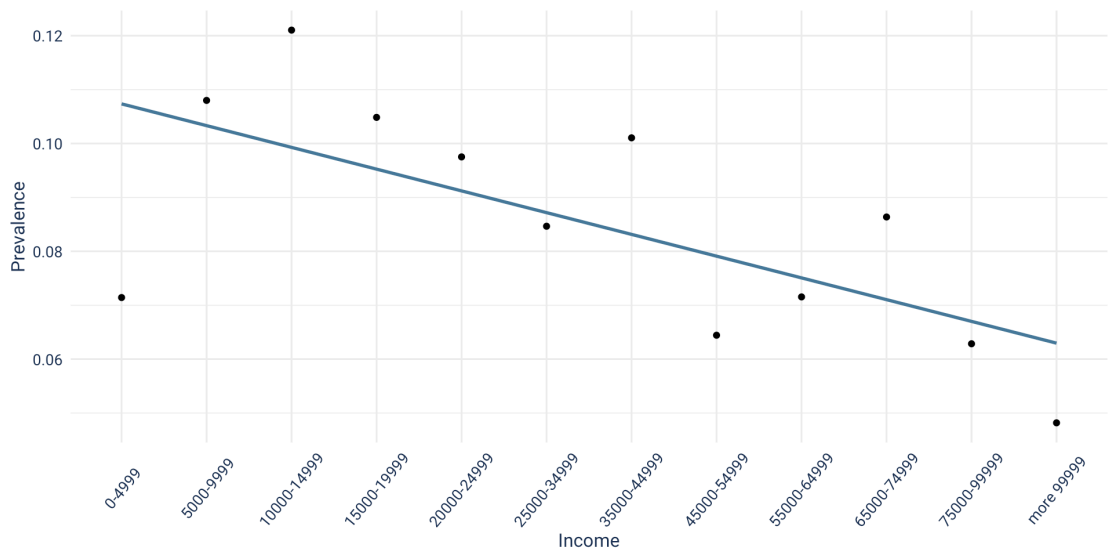
Group	Income	Prev	n
1	0-4999	0.07	182
2	5000-9999	0.11	250
3	10000-14999	0.12	537
4	15000-19999	0.10	515
5	20000-24999	0.10	605
6	25000-34999	0.08	945
7	35000-44999	0.10	851
8	45000-54999	0.06	776
9	55000-64999	0.07	615
10	65000-74999	0.09	521
11	75000-99999	0.06	1066
12	more 99999	0.05	2200

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code



⚠ Ignoring group size

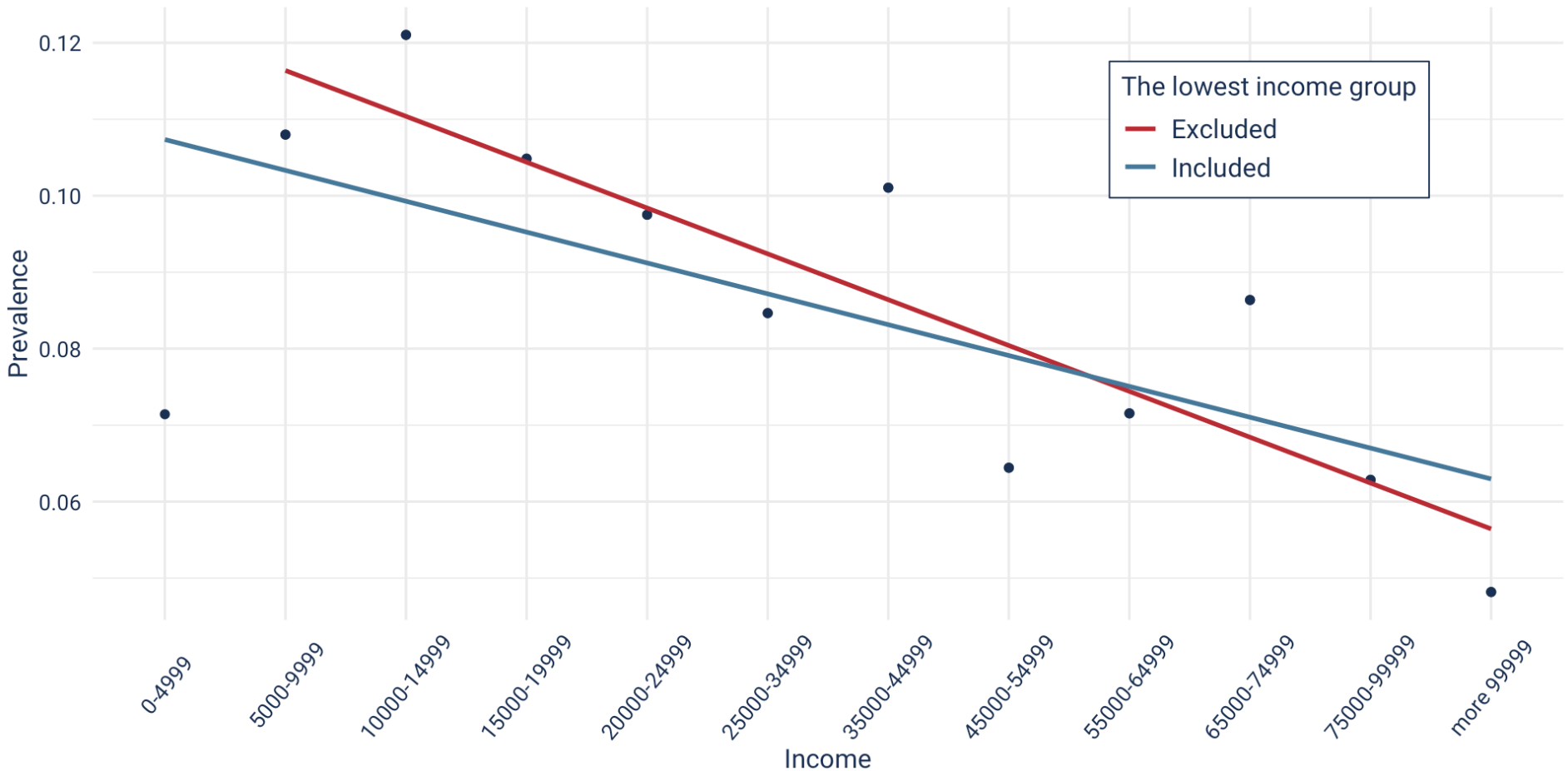
- Tricky to compare across time with changing group sizes
- Sensitive to outlier values from small groups

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code



Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code

Account for the group size

1. Calculate proportions to the toal size
   - $182/n_{total} = 0.02$ for Group #1
   - $250/n_{total} = 0.028$ for Group #2

Group	Income	Prev	n	Prop
1	0-4999	0.071	182	0.02
2	5000-9999	0.108	250	0.028
3	10000-14999	0.121	537	0.059
4	15000-19999	0.105	515	0.057
5	20000-24999	0.098	605	0.067
6	25000-34999	0.085	945	0.104
7	35000-44999	0.101	851	0.094
8	45000-54999	0.064	776	0.086
9	55000-64999	0.072	615	0.068
10	65000-74999	0.086	521	0.057
11	75000-99999	0.063	1066	0.118
12	more 99999	0.048	2200	0.243

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code

Account for the group size

1. Calculate proportions to the toal size
2. Calculate cumulative proportions
    - $0 + 0.02 = 0.02$ for Group #1
    - $0.02 + 0.028 = 0.048$ for Group #2

Group	Income	Prev	n	Prop	Cum
1	0-4999	0.071	182	0.02	0.02
2	5000-9999	0.108	250	0.028	0.048
3	10000-14999	0.121	537	0.059	0.107
4	15000-19999	0.105	515	0.057	0.164
5	20000-24999	0.098	605	0.067	0.23
6	25000-34999	0.085	945	0.104	0.335
7	35000-44999	0.101	851	0.094	0.429
8	45000-54999	0.064	776	0.086	0.514
9	55000-64999	0.072	615	0.068	0.582
10	65000-74999	0.086	521	0.057	0.64
11	75000-99999	0.063	1066	0.118	0.757
12	more 99999	0.048	2200	0.243	1

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code

Group	Income	Prev	n	Prop	Cum	Mid
1	0-4999	0.071	182	0.02	0.02	0.01
2	5000-9999	0.108	250	0.028	0.048	0.034
3	10000-14999	0.121	537	0.059	0.107	0.077
4	15000-19999	0.105	515	0.057	0.164	0.135
5	20000-24999	0.098	605	0.067	0.23	0.197
6	25000-34999	0.085	945	0.104	0.335	0.283
7	35000-44999	0.101	851	0.094	0.429	0.382
8	45000-54999	0.064	776	0.086	0.514	0.471
9	55000-64999	0.072	615	0.068	0.582	0.548
10	65000-74999	0.086	521	0.057	0.64	0.611
11	75000-99999	0.063	1066	0.118	0.757	0.698
12	more 99999	0.048	2200	0.243	1	0.879

Account for the group size

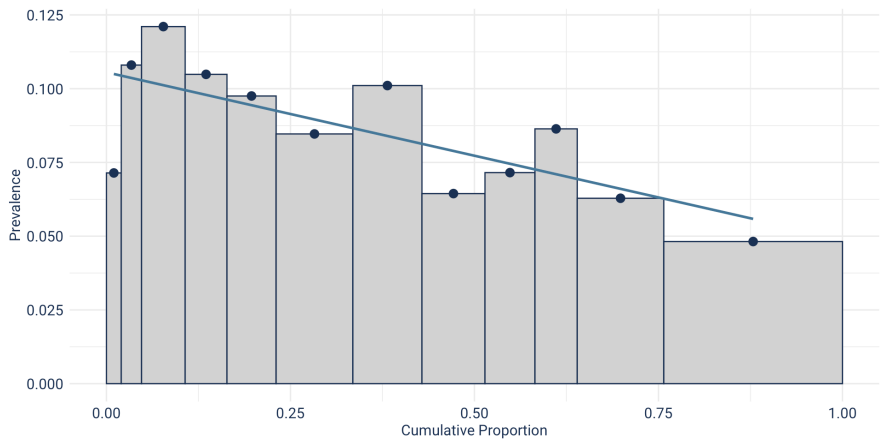
1. Calculate proportions to the toal size
2. Calculate cumulative proportions
3. Regression on midpoints
    - Group #1 range: 0-0.02
        - → mid=0.01
    - Group #2 range: 0.02-0.048
        - → mid=0.034
        - → $0.048 - 0.028/2$

Summary Measures for Social Inequalities

Regression-based measures

Example: Prevalence of diabetes by household income in the NHANES sample

▶ Code



▶ Code

term	estimate	std.error	statistic	p.value
(Intercept)	0.106	0.0075	14.1	0.000000063
midpoint	-0.057	0.0166	-3.4	0.006648294

- The estimated slope for `midpoint`: -0.057
  - → **Slope Index of Inequality (SII)**
    - Summary measure of absolute inequality
  - → Interpretation?
    - Absolute change in the prevalence for "one unit increase" in X
      - Moving from the bottom to the top of the income hierarchy
      - Can be flipped with reverse coded ranks

Summary Measures for Social Inequalities

Regression-based measures

- Regression Models
  - → Grouped data: $E[Y_j|mid_j] = \beta_0 + = \beta_1 mid_j$
  - → Individual data: $E[Y_i|cum_i] = \beta_0 + = \beta_1 cum_i$
- SII (absolute inequality): β_1
- Relative Index of Inequality (RII)
  - → $SII/\bar{Y}_j$ (Pamuk 1985)
  - → $\beta_0/(\beta_0 + \beta_1)$ (Kunst and Mackenbach 1994)
    - Ratio of the least vs most advantaged

(!) Assumptions?

- Social groups can be ordered (e.g., income)
- Linearity
  - → Can use non-linear models and predict $E[Y_i|cum_i = 0]$ and $E[Y_i|cum_i = 1]$

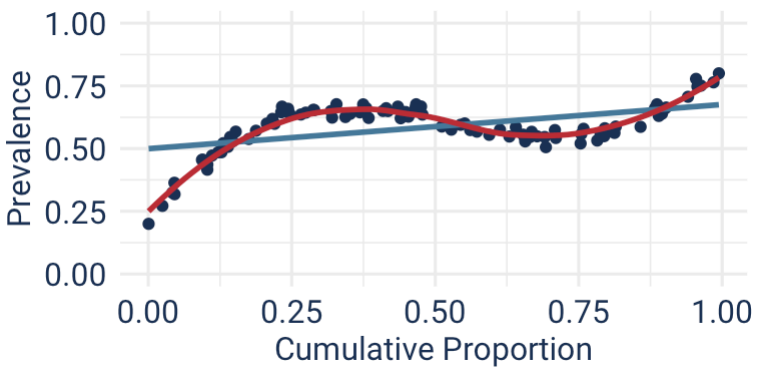
Summary Measures for Social Inequalities

Regression-based measures

- Simulated data with $E[Y_i|cum_i = 0] = 0.2$ and $E[Y_i|cum_i = 1] = 0.8$
  - → True SII: $0.8 - 0.2 = 0.6$

Nonlinear

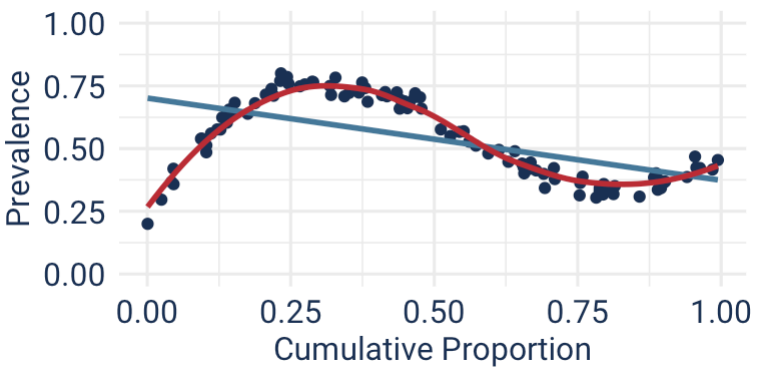
▶ Code



- SII from linear regression: 0.18
  - → Underestimated disparity

Non-monotonic

▶ Code



- SII from linear regression: -0.33
  - → Is the “true” SII (0.6) meaningful?

Summary Measures for Social Inequalities

Regression-based measures

Real-world application of SII and RII (Mackenbach et al. 2008)

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SPECIAL ARTICLE

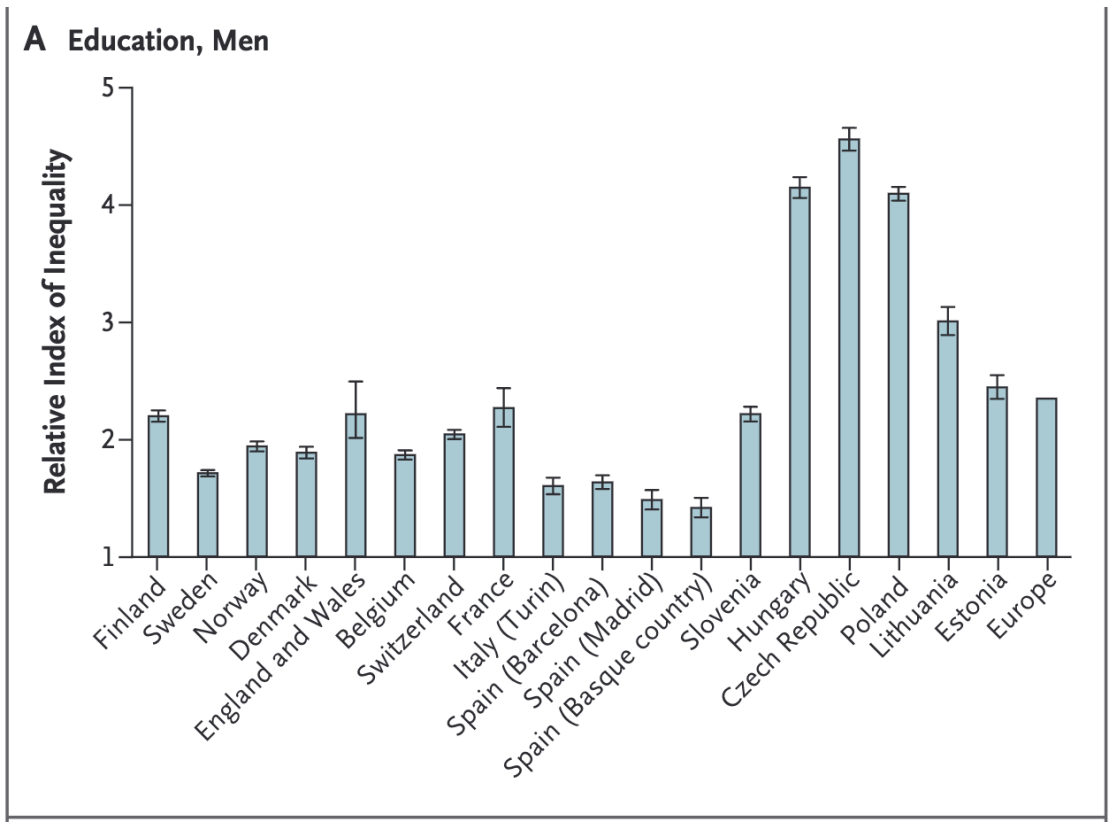
Socioeconomic Inequalities in Health in 22 European Countries

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Summary Measures for Social Inequalities

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RII for education-based inequalities in all-cause mortality rate among men



Interpretation?

Summary Measures for Social Inequalities

Impact measures

Disease rates across social groups

SES	Rate (Y)	Size	Fraction
Low	0.5	40	0.25
Middle	0.3	100	0.625
High	0.2	20	0.125

- Fraction: e.g., $40/(40+100+20) = 0.25$
- $\bar{Y} = 0.5 * 0.25 + 0.3 * 0.625 + 0.2 * 0.125 = 0.3375$
  - → Rate in the total population
- $Y_{ref} = 0.2$
  - → Rate among the "best-off" group

Population Attributable Risk (PAR)

- Often used for disease risk factors
- $\bar{Y} - Y_{ref} = 0.3375 - 0.2 = 0.1375$
  - → Absolute inequality
  - → "If all SES groups had the health of the high SES group, the disease rate in the population would be 0.1375 smaller."

Populatin Attributable Fraction (PAF)

- $PAR/\bar{Y} = 0.1375/0.2 = 0.6875$
  - → Relative inequality
  - → "If all SES groups had the health of the high SES group, 68.8% of cases would not have occurred"

Intersectionality

- Health differences across groups defined by multiple social identities
  - → e.g., gender * race

Analytic approaches for assessing intersectionality

1. **Subgroup (or regression with high-order product terms)**
   - e.g., (Sawada et al. 2025)
2. **Mixed effects modeling**
   - MAIHDA (Evans et al. 2024)

Summary 3

- Composite measures of social inequalities
  - → Alternative to (potentially too many) pair-wise comparisons
- Mean difference from a reference group
  - → Absolute and relative (Index of Dispairty)
- Regeression-based measures for ordered variables
  - → SII and RII
    - Built-in weighting for group size
    - Plot the data and select a model (or use other metrics)
- Impact measures

Assignment (due September 15th 9:59am)

- **Problem set #1**
  - → Read the HTML file for instructions
  - → Ways to submit your assignment:
  1. (Recommended) Modify the `qmd` file to include your answers
     - → Then submit the rendered HTML file
       - This is a fantastic way to practice reproducible reporting using Quarto!
  2. Or submit your answers as a Word document
- **Reading quiz #2**
  - → In the blackboard course website under the “Week 2” module

References

Braveman P. Health disparities and health equity: Concepts and measurement. Annual review of public health. 2006;27(1):167–94.

Evans CR, Leckie G, Subramanian S, Bell A, Merlo J. A tutorial for conducting intersectional multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA). SSM-population health. 2024;26:101664.

Galea S, Hernán MA. Win-win: Reconciling social epidemiology and causal inference. American journal of epidemiology. 2020;189(3):167–70.

Harper S, Lynch J. Methods for measuring cancer disparities: Using data relevant to healthy people 2010 cancer-related objectives. 2005;

Harper S, Lynch J. Health Inequalities: Measurement and Decomposition. SSRN Electronic Journal [Internet]. 2016; Available from: http://dx.doi.org/10.2139/ssrn.2887311

Jackson JW. Meaningful causal decompositions in health equity research: Definition, identification, and estimation through a weighting framework. Epidemiology. 2021;32(2):282–90.

Krieger N. Epidemiology and the people's health: Theory and context. Oxford University Press; 2024.

Kunst AE, Mackenbach JP. Measuring socio-economic inequalities in health. 1994;

Mackenbach JP, Stirbu I, Roskam AJR, Schaap MM, Menvielle G, Leinsalu M, et al. Socioeconomic inequalities in health in 22 european countries. New England journal of medicine. 2008;358(23):2468–81.

Nakagomi A, Tsuji T, Saito M, Ide K, Kondo K, Shiba K. Social isolation and subsequent health and well-being in older adults: A longitudinal outcome-wide analysis. Social Science & Medicine [Internet]. 2023 Jun;327:115937. Available from: http://dx.doi.org/10.1016/j.socscimed.2023.115937

Okuzono SS, Shiba K, Kim ES, Shirai K, Kondo N, Fujiwara T, et al. Ikigai and subsequent health and wellbeing among Japanese older adults: Longitudinal outcome-wide analysis. The Lancet Regional Health - Western Pacific [Internet]. 2022 Apr;21:100391. Available from: http://dx.doi.org/10.1016/j.lanwpc.2022.100391

Pamuk ER. Social class inequality in mortality from 1921 to 1972 in england and wales. Population studies. 1985;39(1):17–31.

Sawada A, Tsuno K, Shiba K. Gender differences in subjective wellbeing in japan: An intersectionality approach. Wellbeing, Space and Society. 2025;100270.

Shiba K, Cowden RG, Gonzalez N, Lee MT, Lomas T, Lai AY, et al. Global trends of mean and inequality in multidimensional wellbeing: Analysis of 1.2 million individuals from 162 countries, 2009–2019. Frontiers in Public Health. 2022 a;10:824960.

Shiba K, Daoud A, Hikichi H, Yazawa A, Aida J, Kondo K, et al. Heterogeneity in cognitive disability after a major disaster: A natural experiment study. Science Advances [Internet]. 2021 Oct a;7(40). Available from: http://dx.doi.org/10.1126/sciadv.abj2610

Shiba K, Hikichi H, Okuzono SS, VanderWeele TJ, Arcaya M, Daoud A, et al. Long-Term Associations between Disaster-Related Home Loss and Health and Well-Being of Older Survivors: Nine Years after the 2011 Great East Japan Earthquake and Tsunami. Environmental Health Perspectives [Internet]. 2022 Jul b;130(7). Available from: http://dx.doi.org/10.1289/EHP10903

Shiba K, Kawahara T. Using Propensity Scores for Causal Inference: Pitfalls and Tips. Journal of Epidemiology [Internet]. 2021 Aug 5;31(8):457–63. Available from: http://dx.doi.org/10.2188/jea.JE20210145

Shiba K, Kawahara T, Aida J, Kondo K, Kondo N, James P, et al. Causal Inference in Studying the Long-Term Health Effects of Disasters: Challenges and Potential Solutions. American Journal of Epidemiology [Internet]. 2021 Mar 17 b;190(9):1867–81. Available from: http://dx.doi.org/10.1093/aje/kwab064

Shiba K, Torres JM, Daoud A, Inoue K, Kanamori S, Tsuji T, et al. Estimating the Impact of Sustained Social Participation on Depressive Symptoms in Older Adults. Epidemiology [Internet]. 2021 Jun 21 c;32(6):886–95. Available from: http://dx.doi.org/10.1097/EDE.0000000000001395

Yazawa A, Shiba K, Inoue Y, Okuzono SS, Inoue K, Kondo N, et al. Early childhood adversity and late-life depressive symptoms: unpacking mediation and interaction by adult socioeconomic status. Social Psychiatry and Psychiatric Epidemiology [Internet]. 2022 Feb 1;57(6):1147–56. Available from: http://dx.doi.org/10.1007/s00127-022-02241-x

Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. American Journal of Epidemiology [Internet]. 2004 Apr 1;159(7):702–6. Available from: http://dx.doi.org/10.1093/aje/kwh090