Upward or Downward Mobility:

Longitudinal residential trajectories and risk for preterm birth

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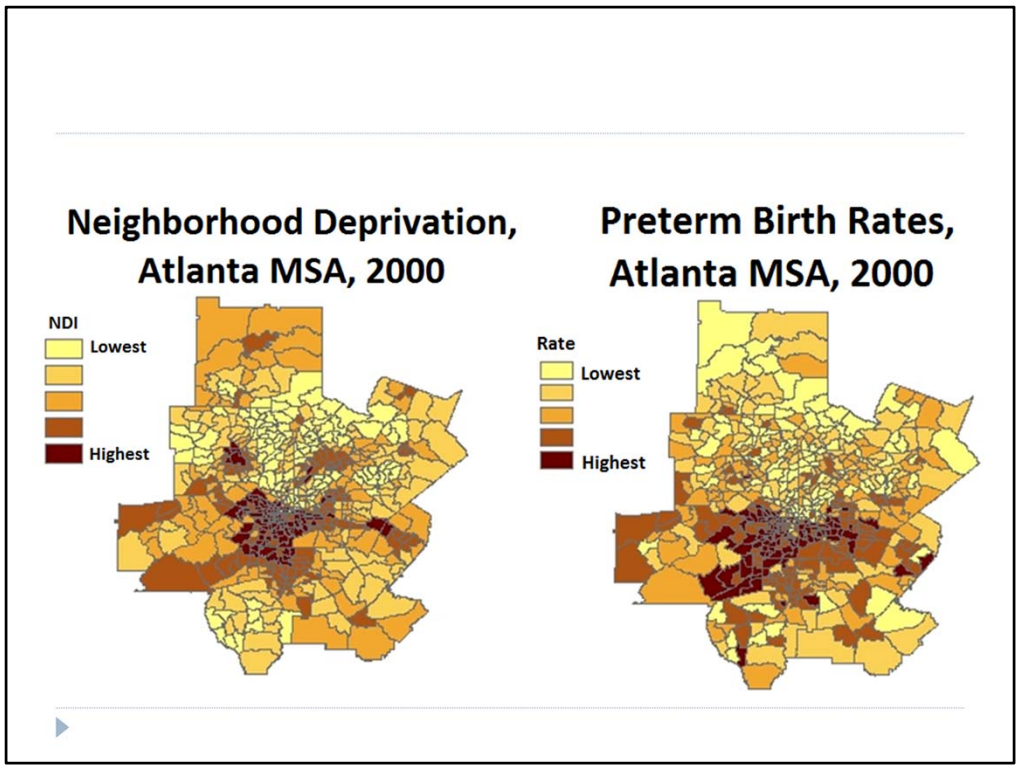
- Objective: To describe a new approach to neighborhood effects studies based on residential mobility and demonstrate this approach in the context of neighborhood deprivation and preterm birth.
- Key Points:
  - Associations between neighborhood characteristics and health outcomes are confounded by selection factors.
  - The standard single time-point design often does not adequately control this confounding.
  - A residential-mobility based approach which draws comparisons between individuals who share a baseline neighborhood can control for some of the confounding by selection factors.
  - This approach has been demonstrated by our study of neighborhood deprivation and preterm birth.

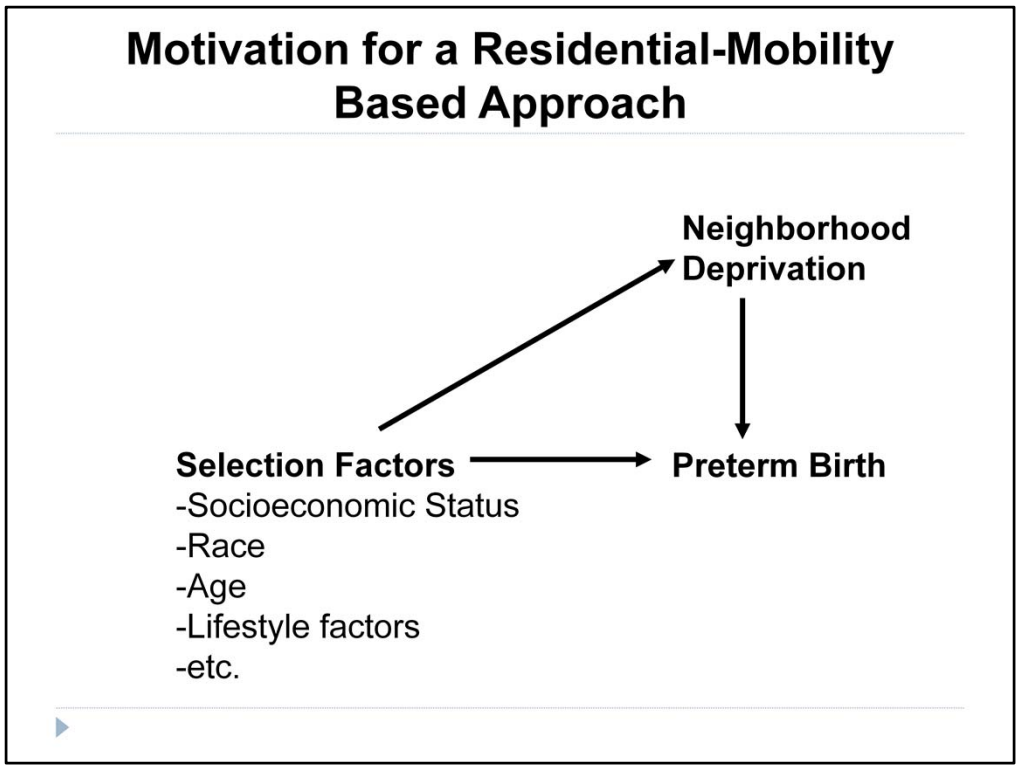


- Motivation for a new study design:
  - These two maps show the 10-county Atlanta, GA metropolitan area.
  - On the right are quintiles of neighborhood deprivation as measured by the Neighborhood Deprivation Index applied to census tracts.
  - On the left are quintiles of preterm birth rates by census tract.
  - At a glance, we can see similarities between the two patterns with overlap between high deprivation and high preterm birth rate tracts as well as between low deprivation and low preterm birth rate.

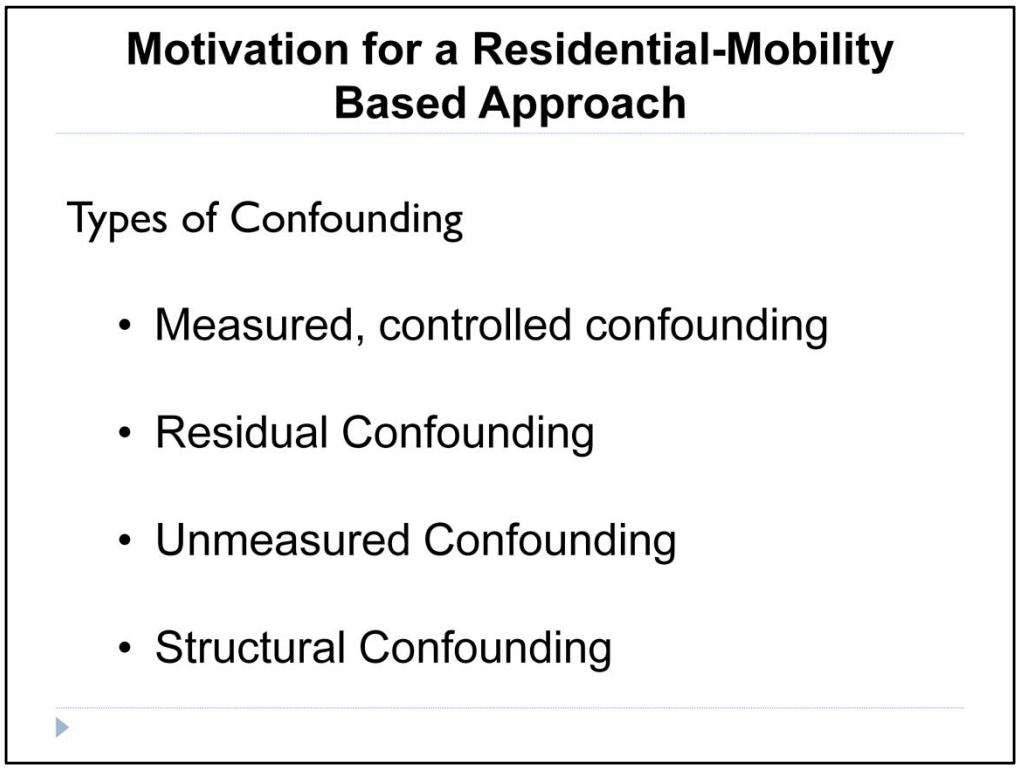
Proportion of births preterm by neighborhood deprivation, Atlanta GA, 1994-2007

Deprivation Quintile	Percent of Births Preterm	(95% Confidence Interval)
High Deprivation	13.9%	(12.8, 15.1)
Mid – High	11.3%	(10.4, 12.3)
Mid	9.8%	(9.0, 10.6)
Mid – Low	8.4%	(7.8, 9.1)
Low Deprivation	7.3%	(6.7, 7.9)

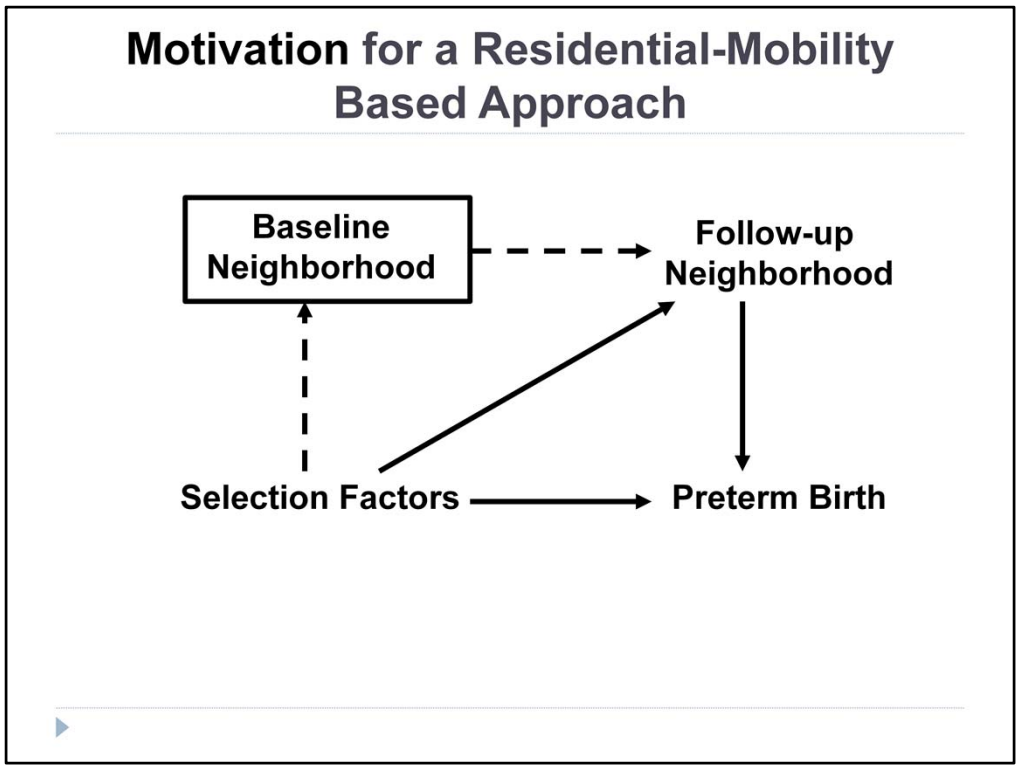
- Motivation for a new study design:
  - Quantifying the pattern observed on the previous slide, we see there are significant differences between preterm birth rates within different quintiles of neighborhood deprivation.
  - In the high deprivation quintile the rate of preterm birth is nearly twice the rate in the low deprivation quintile.
  - However, we would like to examine the causal association, implying that our conclusions must reach the individual level. Based only on this data, individual level inferences would be an ecological fallacy.
  - The direction the field has taken has been to use hierarchical or multi-level regression. This strategy contrasts preterm birth outcomes between individuals living in high deprivation neighborhoods and those in low deprivation neighborhoods while controlling for individual-level differences between people.
  - These studies have fairly consistently found an association, with odds ratios in the range from 1.1 to 1.7.
  - However, there has been considerable discussion in the literature on the barriers to causal inference when using this study design and analytic strategy. (see reference slide)



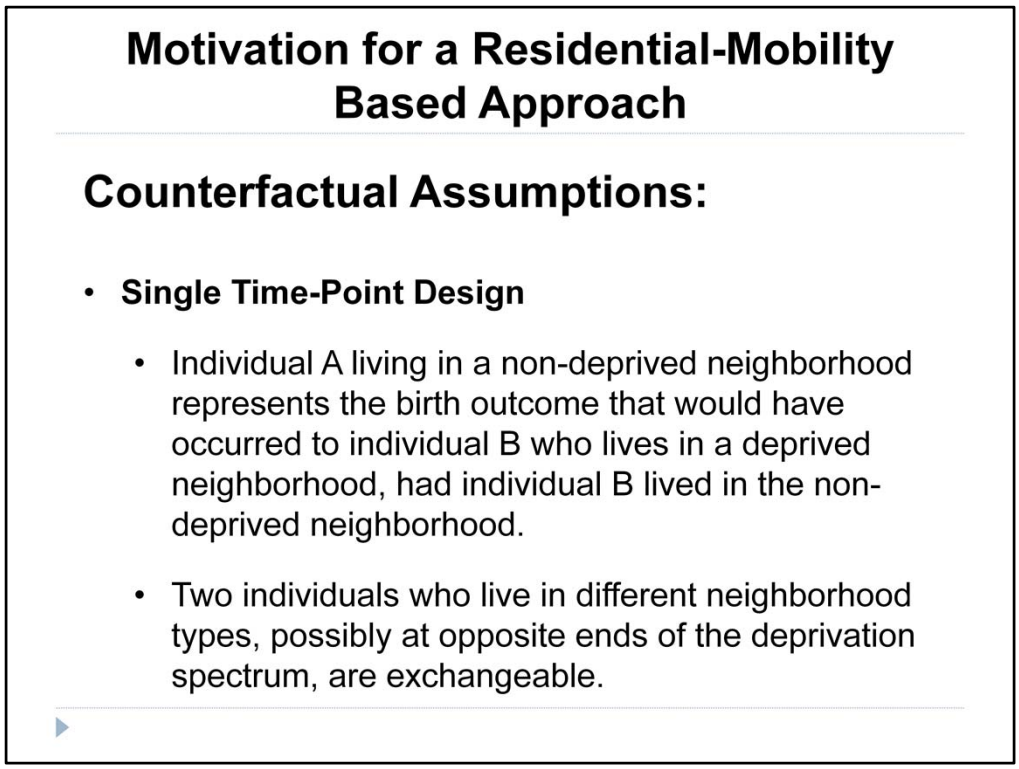
- Motivation for a new study design:
    - One of the barriers to causal inference is the high potential for confounding by selection factors.
    - Selection factors are the factors based on which individuals are selected into different neighborhood types.
    - When selection factors are also associated with the health outcome, in this case preterm birth, they confound the association between the neighborhood characteristic and health outcome.



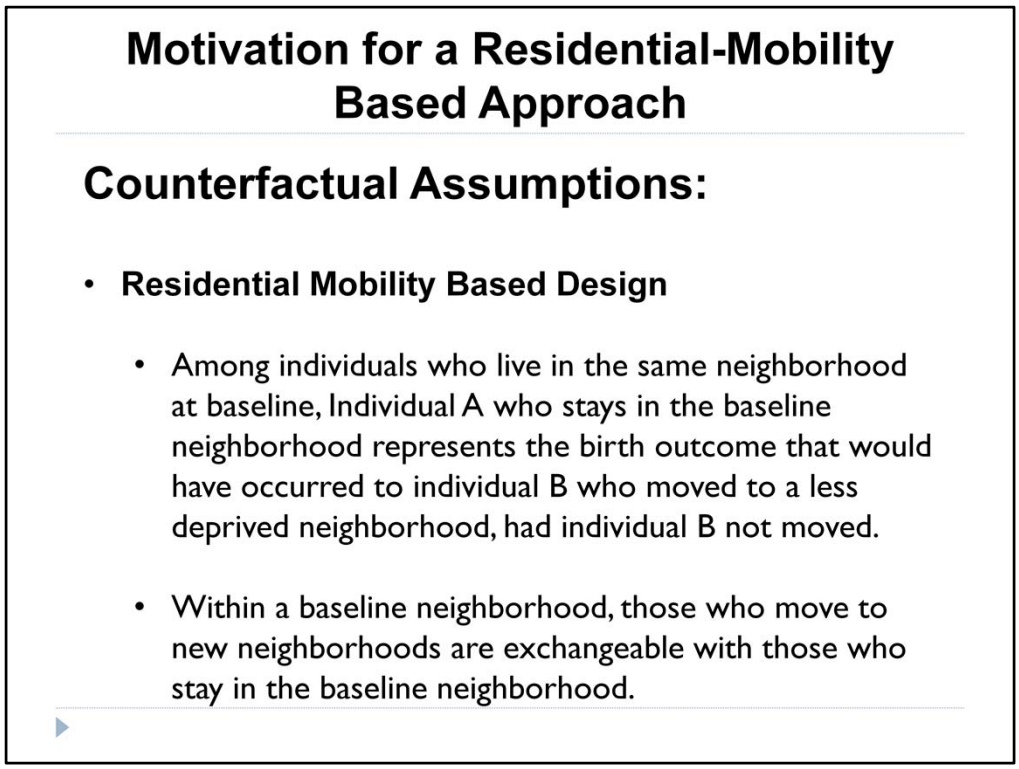
- Motivation for a new study design:
    - Three types of confounding by selection factors are particularly problematic for neighborhood effects studies.
        - Residual Confounding: Occurs when a selection factor is crudely measured, such as using education as the sole measure of socioeconomic status (SES). Particularly problematic due to the strength of SES as a selection factor and the level of detail available in population health data such as birth records.
        - Unmeasured Confounding: Particularly problematic because of lack of research and knowledge on selection factors and lack of measurement of selection factors in population health data.
        - Structural Confounding: Occurs when there is lack of overlap in individual factors between neighborhood types. Statistical control of confounding relies on comparing individuals with the similar selection factors between neighborhood types. When there is near complete separation of individual selection factors between neighborhood types statistical control is not possible. Common structural confounders are race and SES.



- Motivation for a new study design:
  - Returning to the DAG, the benefit of a residential mobility based approach can be demonstrated.
  - Some of the influence of selection factors on the follow-up neighborhood operate through the baseline neighborhood.
  - If we control for the baseline neighborhood, we can indirectly control for some of the confounding by selection factors.
  - If we draw comparisons only between individuals who share a baseline neighborhood, and hence are more likely to have similar selection factors than individuals never sharing a neighborhood, we can substantially reduce the potential for confounding bias.



- Motivation for a new study design:
  - The difference between the two designs can be further demonstrated by examining their counterfactual assumptions.
  - The single time-point design assumes a degree of exchangeability between individuals living in different neighborhood types.

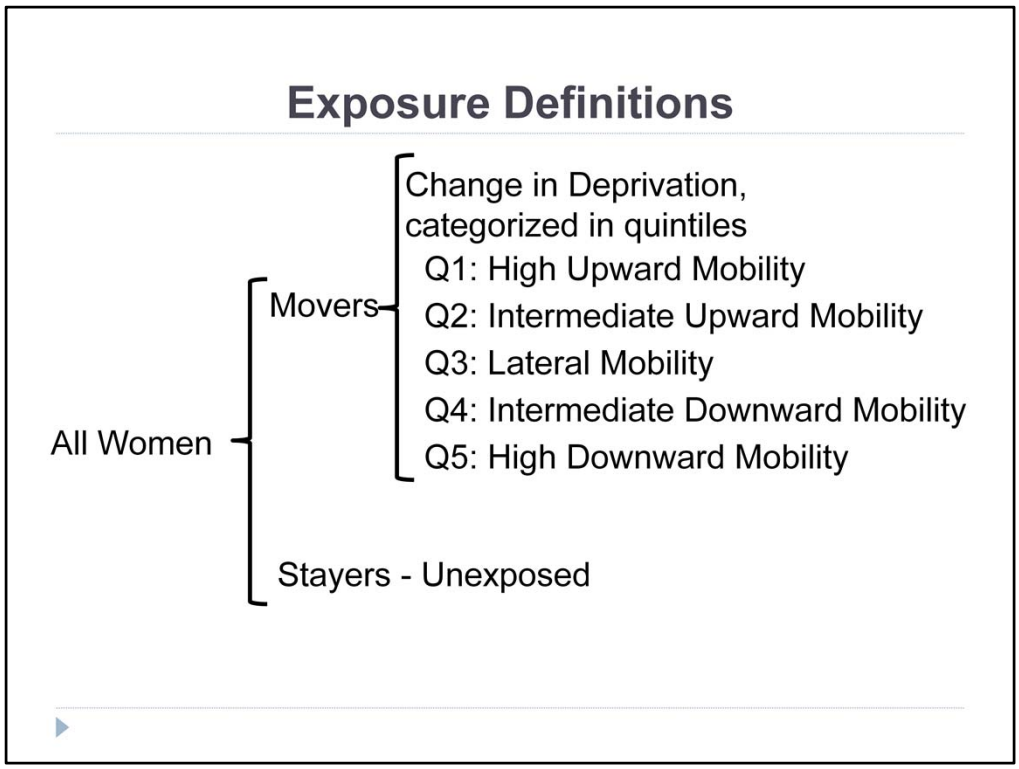


- Motivation for a new study design:
  - The difference between the two designs can be further demonstrated by examining their counterfactual assumptions.
  - The residential mobility based design assumes exchangeability between individuals who were once neighbors.
  - Individuals who move out of the neighborhood to different neighborhood types are compared to those who stay.

Data Source and Structure

- Secondary Analysis
- Maternally linked, residentially geocoded birth records for all births occurring in Georgia from 1994 through 2007
- Restricted to mothers who had at least two births, selected just the first two births for all mothers
- Restricted to mothers for whom both births occurred while living in the 10-county Atlanta MSA. (n= 170,865)
- Linked to Census geography to create neighborhood clusters (564 census tracts)

- Neighborhood Deprivation was estimated using the Neighborhood Deprivation Index (NDI) which uses census measures in five domains: occupation, poverty, housing, employment and education.
- A year-specific estimate of NDI was calculated through linear interpolation between 1990 and 2000 U.S. census' as well as the 2005-2009 American Community Survey.
- The outcome, preterm birth at the 2nd birth, was measured as <37 completed weeks of gestation as reported on the birth record.



- Exposures were defined through a matrix of residential mobility and change in NDI between baseline and follow-up births.
    - Residential mobility was defined as a change in Census tract between baseline and follow-up (binary).
    - Change in deprivation was assessed by the difference between NDI at baseline and follow-up, categorized into quintiles.
    - Those with the greatest decrease in deprivation had high upward mobility.
    - Those with the greatest increase in deprivation had high downward mobility.
    - Those with third quintile change in deprivation had relatively no change in deprivation, moving laterally.
- Stayers, those who did not change census tracts, are unexposed.

Hypothesis

Within a baseline neighborhood, preterm birth risk relative to stayers:

- Upward mobility – Lower Risk
- Downward mobility – Higher Risk
- Intermediate trajectories will have smaller risk differences than high trajectories.
- No risk difference between those with lateral mobility and stayers.

Analysis

$$Y_{ij} = \beta_0 + \boldsymbol{\beta}(MT)_{ij} + \boldsymbol{\gamma}(V)_{ij} + \boldsymbol{\delta}(W)_{ij} + \sum \gamma_j Tract\_ID_j + \varepsilon_{ij}$$

Fixed Effects Model Structure

- $\mathbf{Y_{ij}}$ is the log(odds) of preterm birth for women 'i' living in baseline neighborhood 'j'.
- **MT** is the set of mobility trajectories.
- **V** is the set of individual confounding variables.
- **W** is the set of interactions.
- Each neighborhood, or tract, is entered into the model as a dummy variable such that estimates of odds are conditional on the specific baseline neighborhood of residence, ensuring that comparisons are between women sharing a baseline neighborhood.

Sample SAS code:

```
Proc Surveylogistic;
    class    MT  Tract_ID;
    cluster  Tract_ID;
    Model   PTB = MT  Tract_ID;
run;
```

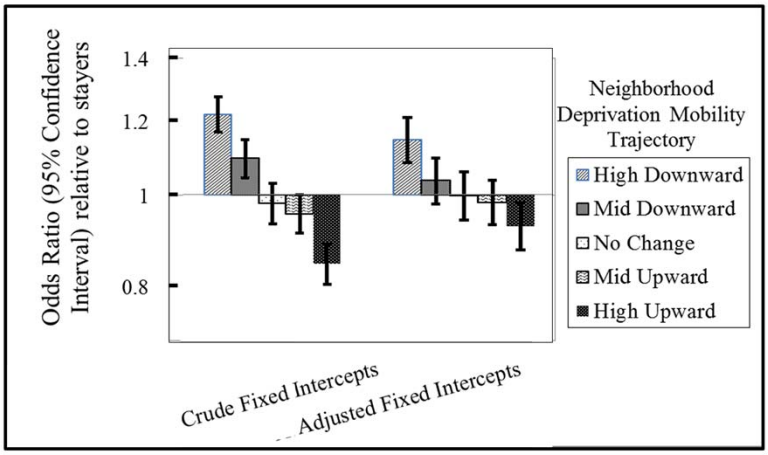
- Analysis Type: Fixed-Intercepts Multi-Level Logistic Regression
- Comparisons are between exposure trajectories within baseline tracts.
- Including the intercept estimate for each tract allows the coefficients for each exposure trajectory to be the average within-tract association across all tracts.
- A primary difference between this design and the single time-point design is that our exposures are within-neighborhood rather than between-neighborhood.

Results

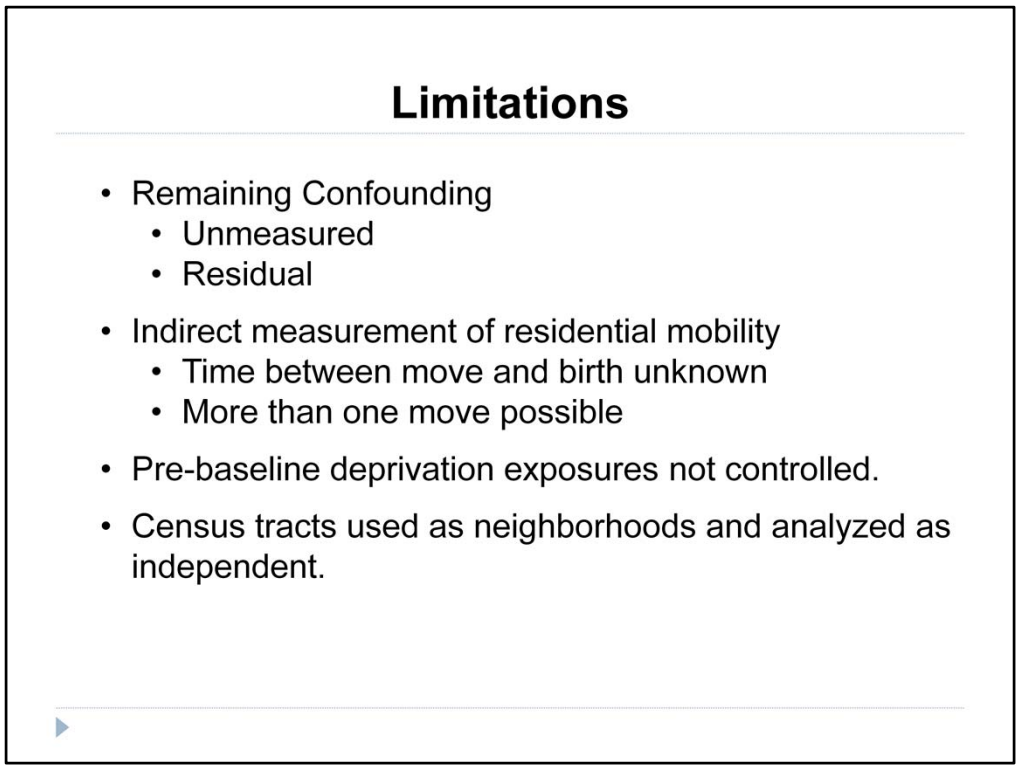
Mobility Trajectory	Crude Model		Final Model*	
	OR	(95% CI)	OR	(95% CI)
High Upward	0.84	(0.80, 0.88)	0.93	(0.88, 0.98)
Intermediate Upward	0.95	(0.91, 1.00)	0.98	(0.93, 1.04)
Lateral	0.98	(0.93, 1.03)	1.00	(0.94, 1.06)
Intermediate Downward	1.09	(1.04, 1.15)	1.04	(0.98, 1.09)
High Downward	1.22	(1.17, 1.27)	1.15	(1.09, 1.21)
Stayers	ref	--	ref	--

*Final model adjusted for maternal race and education and set at median values of interaction terms: Baseline age = 26 years, No baseline preterm birth, Inter-birth Interval = 3 years.

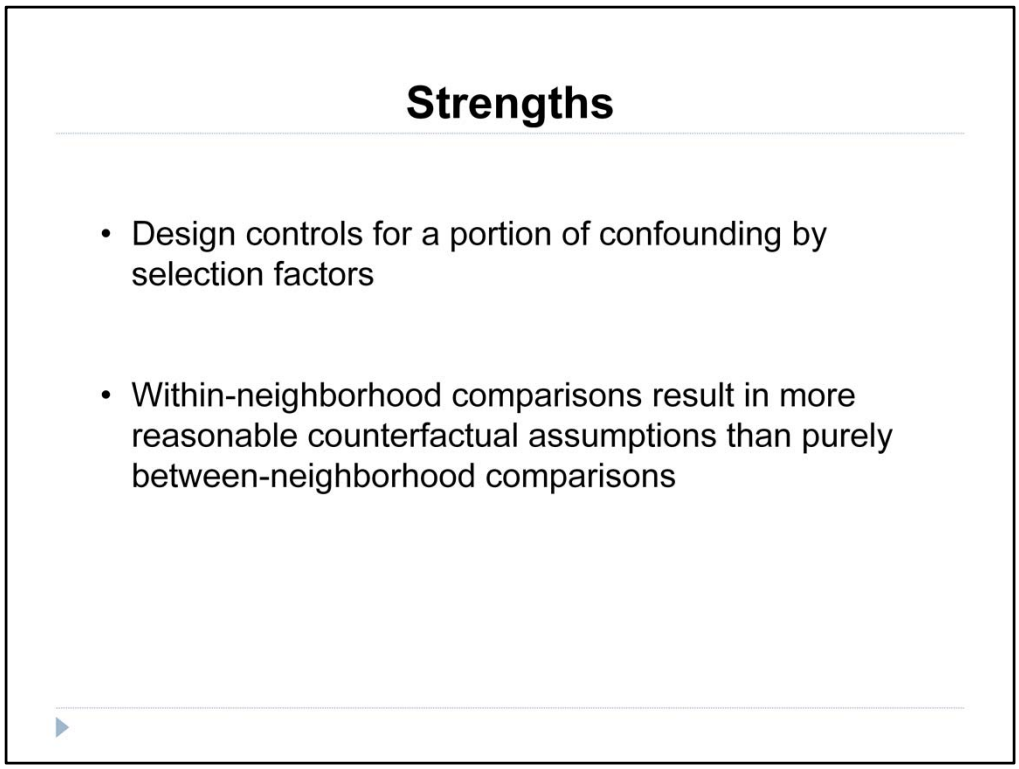
Results



- General Conclusions:
  - Averaged across all baseline neighborhoods, those who move to less deprived neighborhoods have slightly decreased risk of preterm birth relative to those who do not move. Those who move to more deprived neighborhoods have slightly increased risk.
  - If living in a deprived neighborhood is associated with increased preterm birth risk relative to living a non-deprived neighborhood, then we would expect that moving to a more deprived neighborhood would be associated with an increase in risk.
  - Odds ratios from this approach are not directly comparable to odds ratios found in the single time-point approach.



- DAG showed remaining potential for confounding by selection factors.
- Residual Confounding: Modelling process showed maternal education to be a confounder, which likely indicates broader SES is a confounder that is only partially controlled by adjustment for education.
- Unmeasured Confounding: Factors that influence mobility but not baseline neighborhood are not controlled for. For example, an increase in income between baseline and follow-up could be associated both with upward mobility and preterm birth risk and would not be controlled for through conditioning on baseline neighborhood.
- Pre-baseline deprivation exposures could confound the association. If living in a more deprived neighborhood before baseline is associated both with downward mobility and increased preterm birth risk, it could confound the association.



- By drawing comparisons within baseline neighborhoods, we control for much of the confounding due to selection factors that differ between individuals living in different neighborhood types.
- The exposures could potentially be randomized in an experimental framework, which has been seen as a challenge to causal inference in single time-point designs.

Key Points

- Selection factors confound the direct association between neighborhood characteristics and many health outcomes.
- This confounding likely biases associations and is a barrier to causal inference in traditional multi-level regression studies.
- A two time-point, residential-mobility based design can control for much of this confounding.
- This design has been demonstrated in a study of the effect of living in a deprived neighborhood on preterm birth risk.

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A peer-reviewed publication is in process.
A copy of the full-length thesis is available upon request.