Health Before Birth: Why it Matters and What Can be Done?

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Learning Objectives

• Describe economic approaches to the study of early childhood and fetal investments

• Explain the available evidence regarding the long-term effects of early life health

• Discuss approaches to causal inference in this context
OH, GREAT. HUMBLE BEGINNINGS.
• Everyone knows that children from “humble beginnings” are less likely to be successful in life.
• But what are the mechanisms?
• A great deal of research over the past 15 years suggests that conditions very early in life matter.
Maternal Education and Children’s Test Scores (Cunha and Heckman, 2009)
Birth Weight As a Summary Measure of Health at Birth

• Birth weight has been measured over a long period of time and in many populations.
• It is well measured and objectively measured relative to other indicators.
• Birth weight and low birth weight (defined as birth weight less than 2500 grams) are often used as summary measures.
We can examine the relationships between birth weight, test scores, and outcomes using the children of the NLSY

- A survey of the children of women who were 14-21 in 1978.
- What is the relationship between the earliest test scores (measured at ages 3 to 6), educational attainment, and earnings in young adulthood?
- Plot outcomes against the child’s percentile test score and against birth weight.
Figure 1
Correlation between Early Childhood Conditions and Adult Earnings

(a) Wage Earnings at Age 24-27 vs. Mean Test Scores

(b) Log of Wage Earnings at Age 24-27 vs. Mean Test Scores
Incidence of Low Birth Weight in the U.S. (Single Births Only)

- White College 2010
- White College 1989
- African American Dropout
- African American Dropout

The graph shows the incidence rates for different groups, with the African American Dropout category having the highest rate.
People are often tempted to think that persistent differences between groups must be genetic.

- But some physical characteristics have changed over time much more quickly than genetic adaptation allows.
Trends in Heights of Adult Men, cm
(Main source=Steckel and Floud, 1997 for historical data, official statistics for modern)
How Does Rapid Adaptation to the Environment Happen?

• The epigenome determines which parts of the DNA are turned “on” or “off.”
• Environmental factors affect this process.
• Thus, most phenotypes arise through interactions of “nature” and “nurture” (not nature or nurture).
Epigenetics suggests that we should see environmental influences on health at birth, and that these could explain a large fraction of the differences between individuals.

Provides an explanation for something observed in many economic studies: health at birth, as measured by birth weight, is extremely malleable.
Many Economic Studies Link Environmental Factors to Birth Weight

**Social Programs**
- WIC (Hoynes, Page, Stevens ’09)
- Food Stamps (Almond, Hoynes, Schanzenbach, ’11)
- Medicaid (Currie & Gruber ’96)
E.g. Hoynes, Page, Stevens (2009)

- Study the Supplemental Feeding Program for Women, Infants, and Children (WIC).
- Provides supplemental food to pregnant women.
- Program was rolled out on a city/county basis between 1972 and 1979.
- Examine the effect of rollout on birth weight.
Estimated effect of WIC implementation on fraction county births below indicated number of grams
Social Programs
WIC (Hoynes, Page, Stevens ’09)
Food Stamps (Almond, Hoynes, Schanzenbach, ’11)
Medicaid (Currie & Gruber ’96)

Smoking, Drinking, Drugs
(Fertig and Watson, ’09)
(Evans and Ringel, ’97)
(Noonan et al., ’07)
(Currie, Neidell, Schmeider, ’09)

Birth weight
Birth weight

Social Programs
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Smoking, Drinking, Drugs
- (Fertig and Watson, '09)
- (Evans and Ringel, '97)
- (Noonan et al., '07)
- (Currie, Neidell, Schmieder, '09)

Pollution
- (Currie and Walker '10)
- (Currie and Schmieder '09)
- (Currie, Neidell, Schmieder, '09)
- Currie and Neidell, '05
E.g. Currie, Schmeider, and Neidell (2009)

• Look at 1.5 million New Jersey births between 1989 and 2003.

• Confidential version of the data allows us to link siblings and to geocode.

• Select mothers who live near monitors, and examine the effect of changes in criterion air pollutants on fetal health (criterion air pollutants include CO, PM10, PM_{2.5}, NOx, SO_{2}, Lead).
Effect of a 1 Unit Change in CO (Mean=1.6, SD=13) on Incidence of Low Birth Weight

![Bar chart showing the effect of a 1 unit change in CO on the incidence of low birth weight. The chart compares the incidence among all smokers, mothers aged 35 or older, and mothers with risks.]
Birth weight

Social Programs
WIC (Hoynes, Page, Stevens ’09)
Food Stamps (Almond, Hoynes, Schanzenbach, ’11)
Medicaid (Currie & Gruber ’96)

Smoking, Drinking, Drugs
(Fertig and Watson, ’09)
(Evans and Ringel, ’97)
(Noonan et al., ’07)

Maternal Education
(Currie and Moretti, ’03)

Pollution
(Currie and Walker ’10)
(Currie and Schmieder ’09)
(Currie, Neidell, Schmieder, ’09)
Currie and Neidell, ‘05
E.g. Currie and Moretti (2003)

• Use national birth data and a data set of college openings.

• Women who had a college in their county when they were 17 were more likely to go to college.

• Examine the effects of college education on birth outcomes and pathways, including prenatal care, smoking, marital status.
Effect of college opening on education

Avg. years education 1st time mothers 24+
Before & after opening of 4-year college
College education has large effects on maternal behaviors and infant outcomes
Large-scale sibling studies link birth weight to long term outcomes

Birth weight →

Education
(Black, Devereaux, Salvanes, ’07)
(Oreopoulous et al. ’08)
(Currie and Moretti, ‘07)
(Royer, ’09)
Large scale sibling studies link birth weight to long term outcomes

**Birth weight**

**Earnings**
(Black, Devereaux, Salvanes, ’07)

**Education**
(Black, Devereaux, Salvanes, ’07)
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(Currie and Moretti, ‘07)
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Large scale sibling studies link birth weight to long term outcomes

- **Birth weight**
  - **Earnings**
    - (Black, Devereaux, Salvanes, '07)
  - **Health**
    - (Black, Devereaux, Salvanes, '07)
    - (Oreopoulus et al. '08)
    - (Currie et al. '09)
  - **Education**
    - (Black, Devereaux, Salvanes, '07)
    - (Oreopoulus et al. '08)
    - (Currie and Moretti, '07)
    - (Royer, '09)
E.g. Black, Devereux, and Salvanes (2007)

• All Norwegian births from 1967-1997.
• Focus on twins.
• Match to Norwegian registry data for 1982-2002 (i.e. administrative records on educational attainment, earnings, etc.)
• For men, match to military records for 1984-2005 (IQ + height [for subset])
Estimated improvement in outcome with a 10% increase in birth weight
We can show similar long term effects of low birth weight using U.S. data

• E.g. Currie and Moretti (2007) examine 3 generations of California births, grandmothers, mothers, and infants.

  • Compare mothers who are sisters, where one sister is LBW and the other is not.

  • The sister who was LBW gets less education and is more likely to live in a high poverty zip code at the time of her own infant’s birth.

  • **Effect varies with whether the sister was herself born in a high poverty zip code.**
Effect of Maternal LBW on Mother’s Adult Outcomes (Years of Education and Residence in a High Income Zip Code)

-0.25
-0.2
-0.15
-0.1
-0.05
0

Effect on P(High Income)
Effect on Education

Overall
Mother Born in Low Income Zip
Mother Born in High Income Zip
Poor health at birth that is induced by the environment can be transmitted from one generation to the next

- Has been shown in animal studies (e.g. starving rats.)
- We can see this in the California data.
- Look at mothers who are sisters, and estimate effect of mother’s low birth weight on infant’s low birth weight.
Estimated Effect of Mother’s Low Birth Weight on Infant’s P(LBW) by Characteristics of Maternal Residence

- Overall
- Mom in Low Poverty Zip
- Mom in High Poverty Zip
Summary so far…

1) There are large and persistent inequalities in health at birth.
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2) The persistence of disparities cannot be taken as evidence that they are “genetic” – many environmental factors have been shown to influence health at birth.
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2) The persistence of disparities cannot be taken as evidence that they are “genetic” – many environmental factors have been shown to influence health at birth.

3) **Health at birth predicts important future outcomes such as earnings, education, and health.**
Summary so far…

1) There are large and persistent inequalities in health at birth.

2) The persistence of disparities cannot be taken as evidence that they are “genetic” – many environmental factors have been shown to influence health at birth.

3) Health at birth predicts important future outcomes such as earnings, education, and health.

4) There is intergenerational transmission of health at birth, the extent of which depends on social factors.
Early Life Health and the Child’s Adult Outcomes

- Maternal Education
- Early Life Health
  - Pollution Exposure in Pregnancy
  - Smoking, Drinking, Drugs in Pregnancy
  - Nutrition, Illness, Stress in Pregnancy
- Child’s Adult Health
- Child’s Adult Education
- Child’s Adult Earnings
We have shown that being born in a poor place can have negative lifetime consequences

• One way minority (and low SES) neighborhoods might differ from others is in proximity to pollution sources
• The “*Environmental Justice*” literature argues that poor and minority neighborhoods are disproportionately exposed to harmful pollution.

• Given the emerging literature on the harmful effects of pollution on fetal health, such patterns might account for some of the differentials in health at birth.
Existing evidence is conflicting

• Difficult to sort out race, SES, and other factors in cross sectional decennial Census data, especially when “neighborhoods” are often defined at the zip code or county level.
• E.g. urban areas are often more polluted, have a higher fraction minority, but also have higher fractions of more educated, high income workers.
Vital Statistics Natality Data (Birth Certificates)

• A Census of all births.
• Data is continuous (rather than every 10 years).
• Confidential versions of the data (for FL, MI, NJ, PA & TX) allow determination of exact latitude and longitude and therefore distance to pollution sources for ~11,000,000 births between 1989 and 2003.
### U.S. Standard Certificate of Live Birth

#### Child

1. **Child's Name** (First, Middle, Last, Suffix)
2. **Time of Birth (24 hr)**
3. **Sex**
4. **Date of Birth (Mo/Day/Yr)**
5. **Facility Name** (If not institution, give street and number)
6. **City, Town, or Location of Birth**
7. **County of Birth**

#### Mother

8a. **Mother's Current Legal Name** (First, Middle, Last, Suffix)
8b. **Date of Birth (Mo/Day/Yr)**
8c. **Mother's Name Prior to First Marriage** (First, Middle, Last, Suffix)
8d. **Birthplace** (State, Territory, or Foreign Country)
9a. **Residence of Mother**
9b. **County**
9c. **City, Town, or Location**
9d. **Street and Number**
9e. **Apt. No.**
9f. **Zip Code**

#### Father

10a. **Father's Current Legal Name** (First, Middle, Last, Suffix)
10b. **Date of Birth (Mo/Day/Yr)**
10c. **Birthplace** (State, Territory, or Foreign Country)

#### Certifier

11. **Certifier's Name:**
12. **Date Certified**
13. **Date Filed by Registrar**

#### Information for Administrative Use

14. **Mother's Mailing Address:**
15. **Mother Married?** (At birth, conception, or any time between):
   - Yes
   - No
16. **Social Security Number Requested?**
17. **Facility ID (NPI) for Child?**

#### Information for Medical and Health Purposes Only

18. **Mother's Social Security Number:**
20. **Mother's Education** (Check the box that best describes the highest degree or level of school completed at the time of delivery):
   - 8th grade or less
   - 9th - 12th grade, no diploma
   - High school graduate or GED completed
   - Some college credit but no degree
   - Associate degree (e.g., AA, AS)
   - Bachelor's degree (e.g., BA, AB, BS)
   - Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
   - Doctorate (e.g., PhD, EdD) or Professional Degree (e.g., MD, DDS, DVM, LLB, JD)
21. **Mother's Hispanic Origin** (Check the box that best describes whether the mother is Spanish/Hispanic/Latina. Check the “No” box if mother is not Spanish/Hispanic/Latina)
   - Yes, Mexican, Mexican American, Chicana
   - Yes, Puerto Rican
   - Yes, Cuban
   - Yes, other Spanish/Latino
   - No, not Spanish/Latina
   - Other (Specify)
22. **Mother's Race** (Check one or more races to indicate the mother considers herself to be)
   - White
   - Black or African American
   - American Indian or Alaska Native (Name of the enrolled or principal tribe)
   - Asian Indian
   - Chinese
   - Filipino
   - Japanese
   - Korean
   - Vietnamese
   - Other Asian (Specify)
   - Native Hawaiian
   - Guamanian or Chamorro
   - Samoan
   - Other Pacific Islander (Specify)
   - Other (Specify)
### MOTHER

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>29a. Date of First Prenatal Care Visit</td>
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<tr>
<td>29b. Date of Last Prenatal Care Visit</td>
<td></td>
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<tr>
<td>30. Total Number of Prenatal Visits for this Pregnancy</td>
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<tr>
<td>31. Mother’s Height</td>
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<tr>
<td>32. Mother’s Prepregnancy Weight</td>
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<td>33. Mother’s Weight at Delivery</td>
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<tr>
<td>34. Did mother get WIC food for herself during this pregnancy?</td>
<td></td>
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<tr>
<td>35. Number of Previous Live Births (Do not include this child)</td>
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<tr>
<td>35a. Now living</td>
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<tr>
<td>35b. Now Dead</td>
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<tr>
<td>35c. Date of Last Live Birth</td>
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<tr>
<td>36. Number of Other Pregnancy Outcomes (spontaneous or induced losses or ectopic pregnancies)</td>
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<tr>
<td>36a. Other Outcomes</td>
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<tr>
<td>36b. Date of Last Other Pregnancy Outcome</td>
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<td>37. Cigarette smoking before and during pregnancy</td>
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<td>38. Principal source of payment for this delivery</td>
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<td>39. Date last normal menses began</td>
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<tr>
<td>40. Mother’s Medical Record Number</td>
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<tr>
<td>41. Risk factors in this pregnancy (Check all that apply)</td>
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<tr>
<td>Diabetes</td>
<td></td>
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<tr>
<td>Prepregnancy (Diagnosis prior to this pregnancy)</td>
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<tr>
<td>Gestational (Diagnosis in this pregnancy)</td>
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<tr>
<td>Hypertension</td>
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<tr>
<td>Prepregnancy (Chronic)</td>
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<tr>
<td>Gestational (PIH, preeclampsia)</td>
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<tr>
<td>Eclampsia</td>
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<td>Previous preterm birth</td>
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<tr>
<td>Other previous poor pregnancy outcome (Includes perinatal death, small-for-gestational age intrauterine growth restricted birth)</td>
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<tr>
<td>Pregnancy resulted from infertility treatment. If yes, check all that apply:</td>
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<tr>
<td>Fertility-enhancing drugs, Artificial insemination or intrauterine insemination</td>
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<tr>
<td>Assisted reproductive technology (e.g., in vitro fertilization (IVF), gamete intrafallopian tube insemination)</td>
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<td>42. Obstetric procedures (Check all that apply)</td>
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<tr>
<td>Cervical cerclage</td>
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<td>Tocolysis</td>
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<td>External cephalic version:</td>
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<tr>
<td>Successful</td>
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<tr>
<td>Failed</td>
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<tr>
<td>None of the above</td>
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<tr>
<td>43. Onset of Labor (Check all that apply)</td>
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<tr>
<td>Premature Rupture of the Membranes (prolonged, 312 hrs.)</td>
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<td>Precipitous Labor (&lt;3 hrs.)</td>
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<td>Prolonged Labor (3-20 hrs.)</td>
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<tr>
<td>None of the above</td>
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<td>44. Characteristics of labor and delivery</td>
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<tr>
<td>Method of delivery</td>
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<tr>
<td>A. Was delivery with forceps attempted but unsuccessful?</td>
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<tr>
<td>B. Was delivery with vacuum extraction attempted but unsuccessful?</td>
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<tr>
<td>C. Fetal presentation at birth</td>
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<tr>
<td>D. Final route and method of delivery (Check one)</td>
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<tr>
<td>Vaginal/Spontaneous</td>
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<tr>
<td>Vaginal/Forceps</td>
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<tr>
<td>Vaginal/Vacuum</td>
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<tr>
<td>Cesarean</td>
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<tr>
<td>If cesarean, was a trial of labor attempted?</td>
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### MEDICAL AND HEALTH INFORMATION

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<td>41. Risk factors in this pregnancy (Check all that apply)</td>
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<td>Diabetes</td>
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<td>Prepregnancy (Diagnosis prior to this pregnancy)</td>
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U.S. Environmental Protection Agency pollution data

Toxic Release Inventory:

• A response to Union Carbide poison gas leak in Bhopal, India.
• Mandated by the 1986 “Community Right to Know” Act.
• Facilities using more than threshold amounts of listed chemicals are required to report releases.
The TRI has been credited with large reductions in emissions.
A Toxic Release Inventory site...
U.S. Environmental Protection Agency pollution data

Superfund:

• A mechanism for identifying, prioritizing and funding the cleanup of the most hazardous waste sites.

• Begun in 1980 in response to the Love Canal Disaster.
A Superfund cleanup...

Hundreds of orphaned toxic sites have been cleaned up by the Superfund.
• We measure the distance between each mother’s residence and the nearest Toxic Release Inventory or Superfund site to each mother.
• Focus on single births.
• Raw data show large differences in proximity by race/ethnicity and education.
There are large differences by race/ethnicity and education in the probability of being <1.25 miles from a TRI site.
And large differences by race/ethnicity and education in the probability of being <1.25 miles from a Superfund site
But these differences could be due to other characteristics that are correlated with race/education.

To control for other characteristics, estimate models of the probability of being near a site and control for:
mother’s race/ethnicity,
mother’s education,
mother’s age,
birth order,
child gender,
*zip code*, and year of birth.
Using this very detailed data shows minority and low SES infants are more likely to be exposed to toxic releases in utero, even within zip codes.
Pregnant minority and low SES mothers are more likely to live near Superfund sites, even within zip code

![Bar chart showing the difference in the probability of being near a Superfund site for different groups of pregnant mothers. The chart compares White College, Black College, Hispanic College, Black <HS, and Hispanic <HS groups. The graph indicates a higher difference for Hispanic <HS mothers compared to White < HS mothers.]
Sorting Can also be Examined Using Continuous Vital Statistics Data

• The hypothesis is that some groups will be more responsive to changes in environmental amenities than others.

• This will lead to sorting in response to changes in these amenities.
• We ask how the composition of mothers close to a site changes after a Superfund cleanup, compared to the composition of mothers who are a little further away.

• “close” is within 1.24 miles and the comparison group is between 1.24 and 3 miles.

• Focus on births conceived between 4 years before and 4 years after the cleanup.
Effect of Superfund Cleanup on Fraction of Mothers in Demographic Group

- All sites
- Top 1/3 most hazardous sites

Demographic Groups:
- White
- White Coll.
- Black
- Black<HS
- Hispanic
These results suggest that:

• Mothers sort rapidly in response to changes in at least some environmental amenities (such as cleanup of Superfund sites).

• Education is important in determining who is affected.
To understand the importance of residential sorting for infant health, we need an estimate of the health effects of exposure

- Currie, Davis, Greenstone and Walker (2011) use plant openings/closures as an instrument for toxic releases.
- Compare mothers 1 mile from a plant to those 1-2 miles from the same plant.
How Far is “Far Enough” From a Plant?

• EPA has monitored *criterion* air pollutants for decades.

• Began monitoring hazardous air pollutants (HAPs) in 1998 and has added monitors over time. By 2003, there were 84 HAPs being monitored in our study states.

• Match monitoring stations and plants, keeping monitor-plant pairs if plant ever reported emitting the pollutant.
Estimate the falloff in pollution with distance

Figure 1: The Effect of Toxic Plants on Ambient Hazardous Air Pollution
• Using the actual distribution of maternal locations, our estimates imply that ~6% of the gap in LBW between white college educated mothers and black < high school mothers could be due to toxic releases.

• 6% is a large share, but not a majority share, so other influences must also be important.
Summary re: Environmental Justice

- Neighborhoods are a key determinant of exposure to pollution.
- Infants born to minorities and less educated women are significantly more likely to be exposed to toxics in utero.
- Residential sorting in response to changes in environmental amenities tends to benefit white, educated women more than less educated minorities.
- Differences in exposures could explain a significant portion of observed inequalities at birth, but other “environmental” influences are also important.
Is remediation possible? Yes!

• Several programs have been shown to be effective:
  – Prenatal and infant nutrition programs for disadvantaged children.
  – Nurse home visiting programs.
Supplemental Feeding During Pregnancy – e.g. WIC

• Narrowing disparities in health at birth is important.

• WIC offers nutritious food, access to medical care, and counseling to women at risk of poor outcomes. WIC mothers have characteristics that are associated with poor birth outcomes on average: they have lower income, are more likely to smoke, less likely to have fathers listed on the birth certificate, more likely to be on public assistance, and less likely to have adequate housing even compared to other eligible mothers.
But WIC mothers have better outcomes than other eligible moms! (odds ratios for WIC vs. other eligible moms)
Nurse home visiting

• A specific model pioneered by David Olds and collaborators.

• Extensively evaluated using randomized controlled trials with long follow ups.

• Targets “at risk” mothers of firstborns.

• Visits begin in pregnancy and continue at least two years postnatally.

• Visitors are nurses (not “paraprofessionals”) who follow a detailed protocol.
Comparison Treatments vs. Controls (pooling results for Elmira and Memphis experiments)
Conclusions to date

• There is clear evidence that inequality begins well before school age, and indeed, before birth.
• Large differences in health at birth have important consequences for future outcomes.
• Environmental factors (broadly defined) play a critical role.
• These differences can be remediated, but person-based policies may work better than place-based policies.
Research issues going forward:

• Lack of data is an important problem.
• New data collections are costly and time consuming (and may need to wait for cohorts to age to see effects).
• In many cases the data that could be used to address important questions already exists but is not accessible to researchers.
Future Research

• Identifying the main sources of inequality at birth.

• Evaluating policies aimed at giving children an equal start in life, including emphasis on how economic actors react.

• Understanding the relationship between health “capital” and other forms of human capital such as educational attainment and earnings.
This research program is still in its infancy!
Please fill out your evaluation
Thank You!

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