Why Does Place Matter? Community-level Analysis and CER in Understanding Chronic Disease Disparities

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Comparative Effectiveness Research
CTSI Clinical Research Development Seminars
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I have not conflicts of interest to disclose.
Session Objectives

- Rationale and conceptual framework for studying neighborhoods and health
- Review evidence on neighborhood characteristics and cardiometabolic disease
  - CVD/Obesity
  - Diabetes
  - Stroke risk and outcomes
- What to consider in evaluating an analysis of neighborhoods and health
- Sample listing of databases that have geocoded data
Rationale for Studying Neighborhoods and Health
A map of cholera deaths in London, 1840s

A contaminated water pump in Broad Street proved to be the source for the spread of cholera (Drawn by Dr John Snow about 1854)
Age-adjusted Percentage of U.S. Adults Who Were Obese or who had Diagnosed Diabetes

**Obesity (BMI ≥30 kg/m²)**

**1994**

**2000**

**2008**

Cardiometabolic Disease: The Individual Context

- Traditional focus on individual-level behavioral and biological risk factors
- Management also viewed as related to individual choice and medical care
- Resulting Prevention/Treatment strategies:
  - Health education to enhance awareness and motivate individuals to change habits
  - Early detection of risk factors
  - Treatment with medications, established clinical strategies
CVD: the Neighborhood Context

Emerging interest in and evidence on the association between neighborhood context and CVD driven by:

- Epidemiologic studies suggest important geographic variation in obesity and other cardiometabolic disease
- “Obesity epidemic”: role of environmental factors
- Rapid advances and interdisciplinary work in:
  - Geography (Geographic Information Systems)
  - Public health
  - Sociology
  - Urban planning
  - Biostatistical methods to disentangle individual from neighborhood-level effects (e.g. multilevel models)
What is a Neighborhood?

- Geographic area that captures **exposures**
  - Social environments
    - e.g. concentrated wealth or poverty, segregation, social norms, safety
  - Physical / Built environments
    - e.g. parks, sidewalks, toxins
  - Resource environments
    - e.g. educational opportunity, healthy food stores, health care facilities
Neighborhood Environment

- Resource Environment
  - Available goods and services (e.g. access to healthy foods, places to exercise, transportation)
  - Educational and employment opportunities

- Socioeconomic Environment
  - Concentrated poverty or wealth
  - Physical safety
  - Norms and values
  - Social relationships
  - Residential segregation

- Physical Environment
  - Environmental hazards
  - Housing quality
  - Severe weather patterns
Why Might Neighborhood Exposures Matter for Chronic Disease Disparities?

- Separation of poorer persons and racial/ethnic minority groups into disadvantaged communities may play a role in chronic disease disparities.
- Residence in a disadvantaged neighborhood:
  - Fewer educational and employment opportunities
  - Fewer and lower quality clinical resources
  - More barriers to engagement in self care and manage medication, dietary, and exercise regimens
- Certain groups may be particularly vulnerable to deleterious neighborhood influences or may obtain greater benefit from neighborhood resources:
  - Children and Adolescents
  - Oldest residents
Neighborhood Disadvantage and CVD Incidence and Outcomes

Adapted from Diez Roux, 2003
What to Consider in Evaluating an Analysis of Neighborhoods and Health

- Is the study hypothesis driven? Are the mechanisms plausible?
- How is neighborhood defined?
  - Aggregate versus individual census measures
  - Spatial/Physical characteristics (e.g. # of parks; walkability measured by alpha/gamma indices; etc.) – observed (insider/outsider) versus
  - Is the spatial scale appropriate (e.g. MSAs for clinical or segregation characteristics)
- Is the dependent variable appropriately measured?
- Cumulative and Lagged effects
  - Cross-sectional (common) vs. longitudinal vs. expt’l (rare)
  - Data on neighborhood change / participant mobility
- Causal inference
  - Propensity scores / Instrumental variables
Why Conduct Research to Analyze the Relationship between Neighborhoods and Chronic Conditions?

- Understand **mechanisms**
- Understand **interplay** between exposures
- Identify **policy and community** strategies to prevent and treat diabetes and improve health outcomes
- **Superimposed on** more traditional individual level risk factor modification (e.g. medications, clinical care, behavior change)
Neighborhood Socioeconomic Status and CHD Incidence

**SETTING:** Atherosclerotic Risk in Communities (ARIC)
- 15,792 Whites and African Americans, 45-64 y.o. in 1987-89
- Forsyth County, NC; Jackson, MS; Minneapolis MN; Washington County, MD

**DESIGN:** Multilevel analyses of prospective data (mean 9 yrs f/u)
- Neighborhood socioeconomic status (NSES) score:
  - Residential address linked to 1990 US Census block data
  - Constructed proxies for wealth/income, education, occupation
- Coronary Heart Disease (CHD) events: Surveys + Hospital discharge data + Death certificates + Coroner/autopsy reports
- Adjusted for individual SES (income, education, occupation), other demographic and clinical characteristics

# Neighborhood Socioeconomic Status (NSES)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Census Tract Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>• Median household income</td>
</tr>
<tr>
<td>Wealth</td>
<td>• Median value of housing units</td>
</tr>
<tr>
<td></td>
<td>• % Households with interest, dividend, or rental income</td>
</tr>
<tr>
<td>Education</td>
<td>• % Residents &gt;25 with high school degree</td>
</tr>
<tr>
<td></td>
<td>• % Residents &gt;25 with college degree</td>
</tr>
<tr>
<td>Employment</td>
<td>• % Residents in executive, managerial, professional specialty occupation</td>
</tr>
</tbody>
</table>
Neighborhood Socioeconomic Status and CHD Incidence

RESULTS: 615 coronary events in 13,009 participants
- Residents of disadvantaged neighborhoods had higher adjusted risk of disease than residents of advantaged neighborhoods

<table>
<thead>
<tr>
<th>Race</th>
<th>Neighborhood SES</th>
<th>Hazard Ratios (95% CI) for fully adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td>White:</td>
<td>1 (Low)</td>
<td>1.6 1.1, 2.2)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.5 (1.1, 2.0)</td>
</tr>
<tr>
<td></td>
<td>3 (High) – Reference</td>
<td>1.0</td>
</tr>
<tr>
<td>A-A</td>
<td>1 (Low)</td>
<td>1.5 (1.0-2.3)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.5 (1.0-2.4)</td>
</tr>
<tr>
<td></td>
<td>3 (High) – Reference</td>
<td>1.0</td>
</tr>
</tbody>
</table>

CONCLUSIONS: Living in a disadvantaged neighborhood is associated with increased incidence of coronary heart disease

Diez Roux, NEJM, 2001
Neighborhoods and Heart Disease

- Low neighborhood socioeconomic status associated with heart disease:
  - Higher rates / poorer control of cardiovascular risk factors (e.g. hypertension, diabetes)
  - More unhealthy behaviors (smoking, sedentary lifestyle) that increase CHD incidence
  - Higher incident coronary heart disease (CHD)
  - Higher cardiovascular and all-cause mortality
Conceptual Framework: Neighborhood Exposures and CVD/Stroke?

**Neighborhood Risk Factors**
- **Socioeconomic Environment**
  - Neighborhood SES
  - Racial isolation
  - Residential stability
- **Physical Environment**
  - Food resources
  - Walkability / street design
  - Housing quality/ type/density
  - Disorganization

**Individual Risk Factors**
- **Biologic Risk Factors**
  - Hypertension
  - Diabetes
  - Atrial fibrillation
  - Subclinical CVD
  - Cholesterol
- **Behaviors**
  - Smoking
  - Alcohol use
  - Physical activity
  - Diet
- **Indicators**
  - Age, gender, race
  - Education / Income
- **Medical Care**
  - Access to care
  - Quality of care

**Psychosocial Factors**
- Depression
- Social support
- Social networks

**Physiologic Response**
- Traditional and novel biomarkers

**Incident stroke**
**Post-stroke outcomes (e.g., Mortality)**
Analyses

- Stratified by Race
- Multivariate Models
  - Multilevel Models
    - Individual level characteristics
    - Neighborhood level characteristics
  - Multilevel Cox Proportional Hazard ("Frailty") models to examine time to an event (e.g. stroke, death)
- Mediation Analyses
  - Behavioral risk factors
  - Biological risk factors
  - Psychosocial risk factors
NSES: Overall vs. Race-specific quartile ranges
Little overlap between Whites and African Americans
## Incident Ischemic Stroke, Whites Hazard Ratio \( (P) \)

<table>
<thead>
<tr>
<th></th>
<th>Unadjusted</th>
<th>Model 1 (Age, sex, income, education)</th>
<th>Model 2 (Model 1+ behavioral(^1))</th>
<th>Model 3 (Model 1+ biologic(^2))</th>
<th>Model 4 (Model 1 + behavioral + biologic (^{1,2}))</th>
</tr>
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<tbody>
<tr>
<td>Whites (N=3834)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighborhood SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Q1 (Highest)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>• Q2</td>
<td>1.34 (0.02)</td>
<td>1.27 (0.07)</td>
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<td>1.21 (0.15)</td>
<td>1.21 (0.14)</td>
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<tr>
<td>• Q3</td>
<td>1.43 (0.005)</td>
<td>1.27 (0.07)</td>
<td>1.26 (0.08)</td>
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<td>1.16 (0.26)</td>
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<tr>
<td>• Q4 (Lowest)</td>
<td>1.56 (0.0004)</td>
<td>1.32 (0.04)</td>
<td>1.30 (0.06)</td>
<td>1.16 (0.29)</td>
<td>1.15 (0.32)</td>
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\(^1\)Behavioral Risk Factors – smoking, alcohol use, and diet;

\(^2\)Biologic Risk Factors – EKG abnormalities, subclinical cardiovascular disease, hypertension, diabetes, LDL-c

Brown et al., *Stroke*, 2011
### Incident Ischemic Stroke, Whites and Blacks Hazard Ratio (P)

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</tr>
<tr>
<td>• Q1 (Highest)</td>
<td>1.00</td>
<td>1.00</td>
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|                          |            |                                       |                                     |                                   |                                               |
| **African Americans**    |            |                                       |                                     |                                   |                                               |
| (N=785)                  |            |                                       |                                     |                                   |                                               |
| Neighborhood SES         |            |                                       |                                     |                                   |                                               |
| • Q1 (Highest)           | 1.00       | 1.00                                  | 1.00                                | 1.00                              | 1.00                                          |
| • Q2                     | 0.74 (0.26)| 0.67 (0.15)                           | 0.66 (0.13)                        | 0.75 (0.33)                       | 0.74 (0.31)                                   |
| • Q3                     | 0.84 (0.51)| 0.70 (0.17)                           | 0.63 (0.09)                         | 0.75 (0.31)                       | 0.68 (0.19)                                   |
| • Q4 (Lowest)            | 0.71 (0.24)| 0.60 (0.08)                           | 0.59 (0.09)                         | 0.72 (0.28)                       | 0.72 (0.30)                                   |

\(^1\)Behavioral Risk Factors – smoking, alcohol use, and diet; \(^2\)Biologic Risk Factors – EKG abnormalities, subclinical cardiovascular disease, hypertension, diabetes, LDL cholesterol

Brown et al., *Stroke*, 2011
Conceptual Framework:
Neighborhood Exposures and CVD/Stroke?

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- Biologic Risk Factors
  - Hypertension
  - Diabetes
  - Atrial fibrillation
  - Subclinical CVD
  - Cholesterol
- Behaviors
  - Smoking
  - Alcohol use
  - Physical activity
  - Diet
- Individual Characteristics
  - Age, gender, race
  - Education / Income

Psychosocial Factors
- Depression
- Social support
- Social networks

Physiologic Response
- Traditional and novel biomarkers

Incident stroke
Post-stroke outcomes (e.g., Mortality)
Figure 1: Kaplan-Meier curves of death after incident stroke in 806 CHS participants at (a) 30 days and (b) 1 year post stroke event.
## NSES and Post-stroke Mortality at 1 Year*

<table>
<thead>
<tr>
<th></th>
<th>HR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neighborhood SES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Q1 (Highest)</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>• Q2</td>
<td>1.10 (0.76, 1.60)</td>
<td>0.61</td>
</tr>
<tr>
<td>• Q3</td>
<td>1.43 (0.99, 2.08)</td>
<td>0.06</td>
</tr>
<tr>
<td>• Q4 (Lowest)</td>
<td>1.77 (1.17, 2.68)</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>Stroke Type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Ischemic Stroke (ref)</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>• Hemorrhagic Stroke</td>
<td>4.11 (2.98, 5.68)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>• Unknown Stroke Type</td>
<td>2.67 (1.77, 4.03)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Age (5 year intervals)</strong></td>
<td>1.30 (1.15, 1.46)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>1.41 (1.03, 1.92)</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Total/HDL ratio</strong></td>
<td>0.62 (0.41, 0.96)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*Models are also adjusted for demographics, smoking, alcohol use, diabetes, atrial fibrillation, TIA, subclinical cardiovascular disease, and interaction between NSES and race.*

Brown, *Neurology*, 2013
Can Environments be Considered “Obesogenic” or “Diabetogenic”?

Getty Images – Los Angeles July 24th 2008
Neighborhoods and Diabetes Precursors
Neighborhoods and Diabetes Prevalence
Neighborhoods and Diabetes Prevalence “Designed for Disease”

**SETTING:** 2005 California Health Interview Survey (CHIS)
**DESIGN:** Analysis of food environment and diabetes prevalence
  - Retail Food Environment Index (RFEI): ratio of fast-food stores & convenience stores to grocery stores & produce vendors
**RESULTS:** Residents of communities with highest RFEIs had a 21% higher prevalence of diabetes

Babey, California Center for Public Health Advocacy, April 2008, [http://www.publichealthadvocacy.org/designedfordisease.html](http://www.publichealthadvocacy.org/designedfordisease.html)
Built Environment and Obesity in Disadvantaged Populations

- Systematic review of influence of built environment characteristics on obesity among minorities and socioeconomically disadvantaged persons

- Obesity associated with:
  - Food environment (fewer supermarkets vs. smaller stores or convenience stores)
  - Lack of places to exercise
  - Lack of safety (crime / traffic)
  - Poorer aesthetics, more physical disorder

Lovasi et al., 2009
Neighborhoods and Diabetes Incidence
Physical Activity and Food Resources and Incidence of Type 2 Diabetes

SETTING:
- Multi-Ethnic Study of Atherosclerosis (MESA)
- Population-based survey on neighborhood resources for physical activity (PA) / healthy eating

RESULTS:
- Among 2285 adults, observed 233 new type 2 diabetes cases over 5 years follow-up
- Better neighborhood resources (90TH vs. 10th percentile):
  - Adj. HR=0.62 (95% confidence interval: 0.43-0.88)
  - 38% lower incidence of type 2 diabetes

Strategies for addressing neighborhood contributions to diabetes risk and outcomes
Moving to Opportunity and Tranquility (MTO): A Randomized Social Experiment of Neighborhoods and Diabetes

BACKGROUND:

- Hypothesized from the observational data that neighborhood characteristics might influence health
  - Built environment, health care providers, safety, social norms may all contribute to prevention and management of chronic conditions
- Housing and Urban Development (HUD) demonstration project to understand the social and health outcomes on families of leaving poverty areas.
- “Poverty area” is proxy for large number of neighborhood attributes

Ludwig et al., NEJM, 2012
Moving to Opportunity and Tranquility (MTO): A Randomized Social Experiment of Neighborhoods and Diabetes

SETTING: Randomized housing mobility experiment
- Residents of public housing projects (>40% poverty) in 5 cities (Baltimore, Boston, Chicago, Los Angeles, New York City)

INTERVENTION:
- 3 Conditions:
  - Experimental - voucher only valid in low poverty areas
  - Section 8 - voucher without geographic restriction
  - Control - No vouchers
- >12-year follow-up of 4498 families
- 85% African American or Latina women with children

RESULTS: Experimental group:
- less likely to reside in high poverty areas
- had 13% lower rate of obesity (BMI>35)
- had 22% lower rate of diabetes

Ludwig et al., NEJM, 2012
Moving to Opportunity and Tranquility (MTO)

SETTING:
- Residents of public housing projects (>40% poverty) in 5 cities (Baltimore, Boston, Chicago, Los Angeles, New York City)

INTERVENTION:
- Randomization to one of three conditions:
  - Experimental - voucher only valid in low (<10%) poverty areas in 1990 + short term counseling on housing search
  - Section 8 - voucher without geographic restriction
  - Control - No vouchers
- >12-year follow-up of 4498 families
- 85% African American or Latina women with children

Ludwig et al., *NEJM*, 2012
Moving to Opportunity and Tranquility (MTO)

MEASUREMENTS AND ANALYSES:

- Baseline (1994-1998) and follow up (2008-2010) surveys
- One adult from each family that received low-poverty vouchers and the control group and a randomly selected two thirds of the families in the Section 8 group.
- BMI assessed by measured height and weight
- Diabetes assessed with blood spot analysis to measure A1c

Ludwig et al., NEJM, 2012
Moving to Opportunity and Tranquility (MTO)

RESULTS:

- At 10-15 years follow up, the Experimental group:
  - less likely than the control group to reside in high poverty areas (though this difference decreased over time)
  - had 13% lower rate of obesity (BMI>35) – 31.1% vs. 35.5%
  - had 22% lower rate of diabetes (A1c>6.5) – 14.4% vs. 17.7%

- Possible mechanisms:
  - Higher reported collective efficacy
  - Higher rates of feeling safe
  - Higher rates of having a friend who graduated from college
  - No difference in access to local health care services

Ludwig et al., *NEJM*, 2012
LIMITATIONS:
- Volunteers to study may not have been representative of populations of these cities
- Loss to follow up
- A1c measurement – did not include those with diabetes who may have been successfully treated
- Limited health information at baseline

CONCLUSIONS
- Clinical, public health, and policy implications for obesity and diabetes prevention and potentially management

CONCERN
- What about people who did not / could not leave the high poverty neighborhoods

Ludwig et al., NEJM, 2012
Community Interventions to Improve Diabetes Outcomes on the South Side of Chicago

- Accountable care organizations (ACOs) responsible for broad health outcomes and costs for a defined population
- Example: Community collaboration to improve diabetes outcomes on Chicago’s South Side
  - Quality improvement collaborative: Improve diabetes care in 6 health centers (4 FQHCs)
  - Patient activation: Culturally-tailored patient education
  - Provider communication training
  - Community partnerships that support self-care at home
    - Patient advocate outreach workers
    - Partnerships with organizations/businesses
    - Radio / TV education campaign

Peek et al., 2012
What to Consider in Evaluating an Analysis of Neighborhoods and Health

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Datasets with Geocoded Elements

- Atherosclerotic Risk in Communities (ARIC)
- California Health Interview Study (CHIS)
- Cardiovascular Health Study (CHS)
- Hispanic Community Health Study- Study of Latinos (HCHS- SOL)
- Jackson Heart Study (JHS)
- Look AHEAD (Action for Health in Diabetes)
- MultiEthnic Study of Atherosclerosis (MESA)
- National Health and Nutrition Examination Study (NHANES)
- Translating Research into Action for Diabetes (TRIAD)
- Some VA data
- Geocoding your own data
References


Thank You!