Presenter Disclosure Information

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 chronic conditions
  - Selected examples:
    - CVD/Obesity
    - Diabetes
    - Stroke risk and outcomes
- Unanswered questions about these relationships
Rationale for Studying Neighborhoods and Health
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

<table>
<thead>
<tr>
<th>Year</th>
<th>No Data</th>
<th>&lt;14.0%</th>
<th>14.0-17.9%</th>
<th>18.0-21.9%</th>
<th>22.0-25.9%</th>
<th>≥26.0%</th>
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**Diabetes**

1994  
2000  
2008

<table>
<thead>
<tr>
<th>Year</th>
<th>No Data</th>
<th>&lt;4.5%</th>
<th>4.5-5.9%</th>
<th>6.0-7.4%</th>
<th>7.5-8.9%</th>
<th>≥9.0%</th>
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<td>1994</td>
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<td>2008</td>
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</table>

Cardiovascular 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

Neighborhood Risk Factors

Physical Environment

Social Environment

Behaviors

Stress / Psychosocial Factors

Biologic Risk Factors

Physiologic Responses (e.g. inflammation, endothelial function)

Cardiovascular Disease

Vascular Events
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

Diez Roux, NEJM, 2001
### Neighborhood Socioeconomic Status (NSES)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Census Tract Variable</th>
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<tbody>
<tr>
<td><strong>Income</strong></td>
<td>• Median household income</td>
</tr>
</tbody>
</table>
| **Wealth**  | • Median value of housing units  
               • % Households with interest, dividend, or rental income |
| **Education** | • % Residents $\geq 25$ with high school degree  
                   • % Residents $\geq 25$ with college degree |
| **Employment** | • % Residents in executive, managerial, professional specialty occupation |
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</th>
<th>SES</th>
<th>Hazard Ratios (95% CI) for fully adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td>White:</td>
<td>1 (Low)</td>
<td></td>
<td>1.6 (1.1, 2.2)</td>
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<td></td>
<td>2</td>
<td></td>
<td>1.5 (1.1, 2.0)</td>
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<td></td>
<td>3 (High) – Reference</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>A-A</td>
<td>1 (Low)</td>
<td></td>
<td>1.5 (1.0-2.3)</td>
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<tr>
<td></td>
<td>2</td>
<td></td>
<td>1.5 (1.0-2.4)</td>
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<tr>
<td></td>
<td>3 (High) – Reference</td>
<td></td>
<td>1.0</td>
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</tbody>
</table>

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

Diez Roux, NEJM, 2001
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
- **Individual Characteristics**
  - 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

**Neighborhood Risk Factors**
- **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>
</thead>
<tbody>
<tr>
<td>Whites (N=3834)</td>
<td></td>
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<tr>
<td>Neighborhood SES</td>
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</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><strong>1.34 (0.02)</strong></td>
<td>1.27 (0.07)</td>
<td>1.27 (0.07)</td>
<td>1.21 (0.15)</td>
<td>1.21 (0.14)</td>
</tr>
<tr>
<td>• Q3</td>
<td><strong>1.43 (0.005)</strong></td>
<td>1.27 (0.07)</td>
<td>1.26 (0.08)</td>
<td>1.17 (0.24)</td>
<td>1.16 (0.26)</td>
</tr>
<tr>
<td>• Q4 (Lowest)</td>
<td><strong>1.56 (0.0004)</strong></td>
<td><strong>1.32 (0.04)</strong></td>
<td>1.30 (0.06)</td>
<td>1.16 (0.29)</td>
<td>1.15 (0.32)</td>
</tr>
</tbody>
</table>

\(^1\)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)

<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(^1)+ biologic(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whites (N=3834)</strong></td>
<td></td>
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<tr>
<td>Neighborhood SES</td>
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<tr>
<td>• Q1 (Highest)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>• Q2</td>
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<td>1.21 (0.14)</td>
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<tr>
<td>• Q3</td>
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<td>1.27 (0.07)</td>
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<td>1.17 (0.24)</td>
<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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<tr>
<td><strong>African Americans (N=785)</strong></td>
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<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>0.74 (0.26)</td>
<td>0.67 (0.15)</td>
<td>0.66 (0.13)</td>
<td>0.75 (0.33)</td>
<td>0.74 (0.31)</td>
</tr>
<tr>
<td>• Q3</td>
<td>0.84 (0.51)</td>
<td>0.70 (0.17)</td>
<td>0.63 (0.09)</td>
<td>0.75 (0.31)</td>
<td>0.68 (0.19)</td>
</tr>
<tr>
<td>• Q4 (Lowest)</td>
<td>0.71 (0.24)</td>
<td>0.60 (0.08)</td>
<td>0.59 (0.09)</td>
<td>0.72 (0.28)</td>
<td>0.72 (0.30)</td>
</tr>
</tbody>
</table>

\(^1\)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
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>
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<tbody>
<tr>
<td><strong>Neighborhood SES</strong></td>
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<td></td>
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<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>
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<tr>
<td>• Q3</td>
<td>1.43 (0.99, 2.08)</td>
<td>0.06</td>
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<tr>
<td>• Q4 (Lowest)</td>
<td><strong>1.77 (1.17, 2.68)</strong></td>
<td><strong>0.007</strong></td>
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<tr>
<td><strong>Stroke Type</strong></td>
<td></td>
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<tr>
<td>• Ischemic Stroke (ref)</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>• Hemorrhagic Stroke</td>
<td><strong>4.11 (2.98, 5.68)</strong></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>• Unknown Stroke Type</td>
<td><strong>2.67 (1.77, 4.03)</strong></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Age (5 year intervals)</strong></td>
<td><strong>1.30 (1.15, 1.46)</strong></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td><strong>1.41 (1.03, 1.92)</strong></td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Total/HDL ratio</strong></td>
<td><strong>0.62 (0.41, 0.96)</strong></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
Neighborhoods and Diabetes Precursors
Can Environments be Considered “Obesogenic” or “Diabetogenic”?

Getty Images – Los Angeles July 24th 2008
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
Neighborhood Exposures and Insulin Resistance in Young Adults

SETTING:
- Coronary Artery Risk Development in Young Adults (CARDIA)
- Whites and African Americans, 18-30 y.o. in 1985-86
- Birmingham AL, Chicago IL, Minneapolis MN, Oakland, CA

DESIGN: Multilevel analyses of cross-sectional data from year 10
- Neighborhood socioeconomic status (NSES): 1990 US Census block variables for wealth/income, education, occupation
- Insulin resistance score: BMI; SBP; Fasting HDL, TG, insulin, BG

RESULTS:
- Whites: higher NSES associated with lower adjusted IRS score
- African Americans:
  - High Income: higher NSES associated with lower adj IRS score
  - Lower income: positive assoc. in men / no assoc. in women
- Neighborhood environment may contribute to insulin resistance

Diez Roux, *Diab Care*, 2002
Neighborhood Exposures and the Metabolic Syndrome

SETTING:
- Atherosclerotic Risk in Communities (ARIC) study (1987-99)
- Whites & African Americans, 45-64 yrs, from MD, NC, MS, MN

DESIGN: Multilevel, cross-sectional analyses
- Neighborhood socioeconomic status (NSES): 1990 US Census block variables for wealth/income, education, occupation
- Metabolic syndrome (MetS)*

RESULTS: Women in the most disadvantaged neighborhoods had highest rates of metabolic syndrome*
- African American women: OR=1.20 (1.04, 1.40)
- White women: OR=1.17 (1.00, 1.37)

* SBP>130, DBP>85. BP medications, TG≥150; HDL<50, women; Fasting glucose≥100 mg/dl; waist circumference >88 cm women

Chichlowska, Psychosomatic Med, 2008
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

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

Neighborhoods and Diabetes Management and Outcomes
Does Environment affect Diabetes Outcomes?

**SETTING:** Translating Research Into Action for Diabetes (TRIAD), 18+ years in managed care (CA, HI, IN, NY/NJ, MI, TX)

**RESULTS:** Adults with diabetes who report more neighborhood problems have higher cardiovascular risk

Neighborhoods with more perceived problems
- Crime
- Trash
- Traffic
- Lighting
- Supermarket access

Higher rates of smoking
Worse blood pressure control

- Effect was seen even after adjusting for age, sex, race/ethnicity, education, co-morbidities, and income
- Smoking and elevated blood pressure are strongly associated with worse outcomes in DM

Does Environment affect Diabetes Behaviors? 
Neighborhood Safety

- Is neighborhood safety associated with adherence to diabetes medications?
- California Health Interview Survey (CHIS) 2007 (population-based survey of 43,020 adults)
  - 3401 participants with type 2 diabetes
  - Feeling safe in one’s neighborhood associated with better adherence, adjusted for demographics, access to care, health status, and urbanicity

<table>
<thead>
<tr>
<th>Safe</th>
<th>Unsafe</th>
<th>aOR</th>
<th>P</th>
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<tbody>
<tr>
<td>Delayed filling prescription:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...for any reason</td>
<td>12.8%</td>
<td>21.9%</td>
<td>1.69</td>
</tr>
<tr>
<td>...due to cost</td>
<td>6.8%</td>
<td>12.2%</td>
<td>1.63</td>
</tr>
</tbody>
</table>

Billimek and Sorkin, *JGIM*, 2011
Does Environment affect Diabetes Outcomes? Neighborhood SES and Mortality

**STUDY / SETTING:** Translating Research Into Action for Diabetes
- Multicenter (CA, HI, IN, NY/NJ, MI, TX) study in managed care

**METHODS:** Six-year mortality follow up of 6987 participants using NDI data

**RESULTS:**

<table>
<thead>
<tr>
<th></th>
<th>Cardiovascular Mortality HR (95% CI)</th>
<th>Non-CVD Mortality HR (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Lower NSES</td>
<td>1.79 (1.12, 2.84)</td>
<td>0.96 (0.56, 1.66)</td>
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<tr>
<td></td>
<td>( P=0.01 )</td>
<td>( P=0.89 )</td>
</tr>
</tbody>
</table>

Adjusted for age, sex, race/ethnicity, income, education, smoking, diabetes duration, comorbidity
Racial Segregation and Quality of Diabetes Care

SETTING: 2006 Medical Expenditure Panel Survey (MEPS)
- 2000 US Census data on residential segregation

DESIGN: Cross-sectional analyses
- Assessed 5 dimensions of residential segregation (dissimilarity, isolation, clustering, concentration, centralization)
- Access to Care AND Quality of Care

RESULTS:
- Living in a segregated community was associated with:
  - More recommended diabetes services
  - Higher rates of seeing a primary care provider
  - More problems seeing a specialist

Chan et al., Medical Care, 2012
Summary: Neighborhoods and Diabetes Risk and Outcomes

- Neighborhood disadvantage (NSES, food environment, neighborhood problems) is associated with:
  - Higher prevalence of type 2 diabetes
  - Higher incidence of type 2 diabetes
  - Poorer control of type 2 diabetes
  - Higher CVD mortality among patients with diabetes

- Racial segregation not associated with poorer quality of diabetes care
  - Ethnic enclave effect? …Academic medical centers?

- Hypothesize that improving the environment (e.g. PA and food) might be a viable strategy to reduce diabetes risk / improve outcomes at the population level.
Strategies for addressing neighborhood contributions to diabetes risk and outcomes
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
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
Conclusions

- Neighborhoods matter to diabetes risk and outcomes
  - Observational studies and interventions suggest that neighborhood factors can prevent diabetes or improve diabetes outcomes
- Multidisciplinary translational CER is needed to address the needs of individuals and groups with diabetes or at risk for its complications across a range of clinical and community settings:
  - Clinical and health care system interventions
  - Epidemiologic studies, urban planning, sociology, transportation, educational
  - Social and health care interventions
Limitations & Unanswered Questions
Diabetes Risk and Management

- Do the neighborhood factors that influence type 2 diabetes risk and outcomes differ for children and adults?
- What is the role of ethnic enclaves in diabetes risk and management?
- What are the best strategies for intervening on neighborhood factors that influence diabetes risk and outcomes?
  - How can multi-level interventions, combining policy/marketing, community organization, delivery system, provider, and patient/family components be implemented and sustained to improve diabetes outcomes?
Limitations & Unanswered Questions

Diabetes Management

- Can we move beyond Census measures?
- What roles do access to care and quality of care play in the association between neighborhoods and health?
- Understanding gender and age-related differences in response to neighborhood exposures?
  - Perceived neighborhood safety and aesthetics may play more of a role in walking behaviors for women than men and for older adults than younger adults
- Toxic exposures


Thank You!