Physical Environments, Social Environments, and Risk of Childhood Obesity

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Children’s Health Services Research
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Trivial Pursuit

Question:
What president started the National School Lunch Program?

Answer:
1946: President Harry Truman
“safeguard the health and well-being of the Nation’s children,” and is also said to be a “measure of national security.”
Health Consequences

• Overweight adolescents: 50-70% chance of being obese as adults

• Increased use of alcohol and tobacco

• Lower quality of life
  – decreased activity, school performance, increased fears and sadness, lower quality of relationships with peers
Body Mass Index and CVD Risk Factors
(Bogalusa, 5-10 year olds)

Freedman et al. *Pediatrics* 1999;103:1175-82
Lack of Widely Applicable and Effective Interventions

• Aggressive lifestyle modification (dietary advice, behavioural counseling, physical activity)
  – 10 – 20% reduction in weight in adults
  – 80% failure rate when outcomes measured at 5y or more

• 18 randomized controlled trials focusing on children
  – Only 7 with sample size > 50 participants
  – All conducted at tertiary academic centers and employed highly specialized staff
  – Majority of enrollment consisted of white, middle class, highly motivated families
  – 5 – 10% reduction in weight
CATCH trial

- Child and Adolescent Trial for Cardiovascular Health
- 4 centers (CA, LA, MN, TX) with 56 intervention and 40 control elementary schools
- Comprehensive intervention entailing changes to PE, cafeteria food selections, education, and family component
- 3 year follow-up on 3714 students (73% of initial study cohort)
CATCH results

- At 3 years follow-up:
  - 1% difference (31.6% vs 30.6%) in self-reported daily energy intake from fat
  - 8.8 minutes difference in self-reported daily vigorous activity
  - No difference in smoking behavior, BMI, BP, lipids
Trivial Pursuit

• What household appliance is least likely to be utilized by immigrant families
The Washington Post, Wednesday, October 12, 2005: “Immigrants let dishwashers collect dust,” By Phuong Ly
Trivial Pursuit

- Who is the man on the far left, where is he digging, and what does this have to do with childhood overweight?
The Regenstrief Medical Record System

- in existence since 1974
- 200 million observations for 1.5 million patients
- 3 medical centers
- 30 ambulatory clinics
- all of the emergency departments in the greater Indianapolis region.
LOCAL TRENDS IN CHILDHOOD OVERWEIGHT:
Indiana University Medical Group

- Patients ages 4-16y who had simultaneously documented heights and weights in calendar years 1993 – 2004

- Administrative coding (e.g. billing, physician diagnosis lists) for well-child care on same date as measurements

- Categorized by BMI percentiles as overweight (>95th percentile), or normal weight
## Distribution of Visits by Year and Frequency

<table>
<thead>
<tr>
<th>Year</th>
<th># of visits</th>
<th># of Visits Per patient</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>6342</td>
<td>1 only</td>
<td>44%</td>
</tr>
<tr>
<td>1994</td>
<td>7443</td>
<td>2 or more</td>
<td>46%</td>
</tr>
<tr>
<td>1995</td>
<td>8764</td>
<td>3 or more</td>
<td>22%</td>
</tr>
<tr>
<td>1996</td>
<td>9330</td>
<td>4 or more</td>
<td>11%</td>
</tr>
<tr>
<td>1997</td>
<td>9062</td>
<td>5 or more</td>
<td>6%</td>
</tr>
<tr>
<td>1998</td>
<td>11624</td>
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<td></td>
</tr>
<tr>
<td>1999</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>10598</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>10961</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>11572</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>11411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>9846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Characteristics at First Visit

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td>18,662</td>
<td>49%</td>
</tr>
<tr>
<td><strong>Ages 3 – 5y</strong></td>
<td>21,193</td>
<td>56%</td>
</tr>
<tr>
<td><strong>Ages 6 – 10y</strong></td>
<td>9,423</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Ages 11 – 16y</strong></td>
<td>7,565</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Black</strong></td>
<td>19,974</td>
<td>56%</td>
</tr>
<tr>
<td><strong>Hispanic</strong></td>
<td>2,617</td>
<td>7%</td>
</tr>
<tr>
<td><strong>White</strong></td>
<td>12,437</td>
<td>35%</td>
</tr>
<tr>
<td><strong>Public Insurance</strong></td>
<td>23,089</td>
<td>57%</td>
</tr>
<tr>
<td><strong>Private Insurance</strong></td>
<td>12,323</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Self-Pay</strong></td>
<td>742</td>
<td>2%</td>
</tr>
</tbody>
</table>
Overweight Rate by Race and Age Group

Race:
- Black
- Hispanic
- White

Age Groups:
- 3-5 yrs old
- 6-10 yrs old
- 11-16 yrs old

Data:
- Black:
  - 3-5 yrs old: 12.1%
  - 6-10 yrs old: 17.7%
  - 11-16 yrs old: 22.7%
- Hispanic:
  - 3-5 yrs old: 19.4%
  - 6-10 yrs old: 21.4%
  - 11-16 yrs old: 23.0%
- White:
  - 3-5 yrs old: 13.7%
  - 6-10 yrs old: 16.9%
  - 11-16 yrs old: 21.0%
Predicted age at which 20% of group will have a BMI > 95\textsuperscript{th} percentile
Recap 1

• America is losing the battle against obesity

• Childhood overweight is associated with substantial morbidity

• Sustainable weight loss has not demonstrated in most clinical studies.
  - Successful interventions not easily disseminated
    – Narrow demographic profiles of subjects
    – Very intense and multifaceted

• Patterns in the prevalence and emergence of childhood overweight in this population markedly differ by race/ethnicity and sex.

• Intervention needs to start in early childhood (e.g. pregnancy)
We have compartmentalized physical activity in our lives.
Obesogenic Environment

• Environmental factors that increase caloric intake and decrease energy expenditure “…so manifold and so basic as to be inseparable from the way we live.”
  
  Margaret Talbot (New America Foundation)

• “The current U.S. environment is characterized by an essentially unlimited supply of convenient, inexpensive, palatable, energy-dense foods coupled with a lifestyle requiring negligible amounts of physical activity for subsistence.”

  Hill & Peters 2001

• “Genes load the gun, and environment pulls the trigger.”

  G Bray 1998
Built Environment & Obesity

- Increased urban sprawl is associated with decreased physical activity
- Population density, land use mix, and small scale urban design elements are associated with physical activity and reduced obesity
- Fast food restaurants are more concentrated in low-income neighborhoods
- Brand name supermarkets are less concentrated in low-income neighborhoods
- Living in proximity to supermarkets increases consumption of fruits and vegetables, especially for African American adults
Built Environment and Childhood Overweight

- Parks, playgrounds and recreation programs are associated with increased physical activity and reduced obesity among kids.
- Sidewalks, safe streets and destinations within walking distance from home are associated with increased physical activity.
- Limited samples:
  - All low socioeconomic status
  - Narrow age ranges
  - Crude representation of physical environment
Findings compliment a growing number of adult studies in the public health and urban planning literatures.

Relevance of associations unclear.

Physical activity and dietary behaviors differ from adults.

- Type
- Purpose
- Context
Geographic information systems

- Geocoding medical data enables spatial analysis of relationships between clinical outcomes and large amounts of environmental, social, or other factors.

- Various IU-based systems collect a wide range of information that is spatially indexed:
  - Indianapolis Mapping and Geographic Infrastructure System (IMAGIS)
    - [http://www6.indygov.org/imagis/](http://www6.indygov.org/imagis/)
    - Buildings, roads, waterways, utilities, topographical data
  - Social Assets and Vulnerabilities Indicators Project
    - [http://www.savi.org](http://www.savi.org)
    - School performance measures, US Census results, health, crime, formal and informal neighborhood boundaries, and social services.
  - The Center for Urban Policy and the Environment
    - [http://www.urbancenter.iupui.edu/](http://www.urbancenter.iupui.edu/)
    - Land Use In Central Indiana model (LUCI), which seeks to predict the general trends of development
    - Remote sensing satellite images.
Methods: Neighborhood-level data

- 92% successful geocoding of patient data
- Marion County, IN
  - Indianapolis
  - 12th largest US city
Percent of Total Patients with BMI Percentile > 95th where N >= 100

Year 2002

Legend
- Interstates
- County Boundary
- Township Boundaries

Percent of Patients
- < 20%
- >= 20%
- < 100 Patients
- < 100 Patients

Regenstrief Medical Records System, 1996 - 2002 *
US Census Bureau, 2000

* All Patients Age 3 - 16 with Height/Weight Data
Background

- Increased neighborhood greenness associated with decreased risk of childhood overweight

- Association between neighborhood vegetation and overweight changed across areas with differing population density
Background

- Time spent outdoors is the strongest predictor of physical activity in children
- In 1977, children walked or biked for 15.8% of all their trips; by 1995, children made only 9.9% of their trips by foot or bicycle
- Features of the built environment influence physical activity, especially in choices regarding mode of transit, but how does this translate for children at play?
- Parks and green space contribute to quality of life:
  - Increased walking
  - Increased social cohesion
  - Decreased rates of crime
Objective

• Examine relationship between neighborhood-level plant biomass, residential density, and change in BMI
Methods: Patient data

- Retrospective cohort, 1996 --2000
- Medical records for well-child visits ages 4-16y
- Simultaneously documented heights and weights 24 months apart
- Residential address remained constant
- 2-yr change in body mass index (BMI) z-score
Independent Variables

- 1km street network buffers
- Satellite imagery
  - Greenness
  - Residential Density
Normalized Difference Vegetation Index: NDVI

- NDVI is calculated from the visible and near-infrared light reflected by vegetation.
- Chlorophyll, strongly absorbs visible light for use in photosynthesis.
- The cell structure of the leaves strongly reflects near-infrared light.
- Index ranges from -1 to +1.
Normalized Difference Vegetation Index (NDVI)

- $< 0.1$: barren areas of rock, sand, or snow
- $0.2$ to $0.3$: shrub and grassland
- $0.6$ to $0.8$: temperate and tropical rainforests
Residential Density: Residential units per acre
Analysis

- Stratified by age: 3-5y, 6-11y, 12-15y
- Multiple regression

- Dependent variable: 2-yr change BMI z-score
- Predictors of interest:
  - Category of NDVI
  - Category of residential density

- Co-variates:
  - age, sex, race, insurance status, Median Household Income of Census Tract
Study Group

- \( N = 3901 \)
- Females: 50%
- White: 27%
- Hispanic: 12%
- Black: 61%
- Private Ins: 9%
- Ages 3 – 5: 42%
- Ages 6 – 11: 34%
- Ages 12 – 16: 24%
- Overweight: 21%
Independent variables:
Neighborhood-level data

- Mean NDVI at July
  0.12 (-0.24 to 0.47)
Low greeness
NDVI -0.24 to -0.02
(< 25th %-ile )

Moderate greeness
NDVI -0.021 to 0.02
(interquartile range)

High greeness
NDVI > 0.021
(>75th %-ile)
Moderate residential density
3.5 -- 8 units per acre

Low residential density
< 3.5 units per acre

High residential density
> 8 units per acre
## Results: 3 to 5y group

<table>
<thead>
<tr>
<th>Var</th>
<th>Coef.</th>
<th>P-value</th>
<th>95% Conf Int</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lo NDVI</td>
<td>-0.11</td>
<td>0.20</td>
<td>-0.29 to 0.06</td>
</tr>
<tr>
<td>Hi NDVI</td>
<td>-0.26</td>
<td>0.07</td>
<td>-0.54 to 0.02</td>
</tr>
<tr>
<td>Mod RD</td>
<td>-0.04</td>
<td>0.67</td>
<td>-0.22 to 0.14</td>
</tr>
<tr>
<td>Hi RD</td>
<td>-0.06</td>
<td>0.59</td>
<td>-0.26 to 0.06</td>
</tr>
</tbody>
</table>
### Results: 6 to 11y group

<table>
<thead>
<tr>
<th>Var</th>
<th>Coef.</th>
<th>P-value</th>
<th>95% Conf Int</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lo NDVI</td>
<td>-0.02</td>
<td>0.79</td>
<td>-0.14 to 0.10</td>
</tr>
<tr>
<td>Hi NDVI</td>
<td>0.18</td>
<td>0.11</td>
<td>-0.04 to 0.40</td>
</tr>
<tr>
<td>Mod RD</td>
<td>0.21</td>
<td>0.02</td>
<td>0.04 to 0.40</td>
</tr>
<tr>
<td>Hi RD</td>
<td>0.26</td>
<td>0.01</td>
<td>0.06 to 0.46</td>
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</tbody>
</table>
## Results: 12 to 15y group

<table>
<thead>
<tr>
<th>Var</th>
<th>Coef.</th>
<th>P-value</th>
<th>95% Conf Int</th>
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</thead>
<tbody>
<tr>
<td>Lo NDVI</td>
<td>0.04</td>
<td>0.38</td>
<td>-0.05 to 0.13</td>
</tr>
<tr>
<td>Hi NDVI</td>
<td>-0.17</td>
<td>0.04</td>
<td>-0.33 to -0.004</td>
</tr>
<tr>
<td>Mod RD</td>
<td>0.04</td>
<td>0.56</td>
<td>-0.08 to 0.15</td>
</tr>
<tr>
<td>Hi RD</td>
<td>0.02</td>
<td>0.68</td>
<td>-0.01 to 0.16</td>
</tr>
</tbody>
</table>
Discussion

• Elementary aged children (6 – 11y)
  – Higher residential density of children’s surroundings is associated with increase in BMI z-score

• Adolescents (12-15y)
  – Increased “greeness” of an older child’s surroundings is associated with decrease in BMI z-score
  – These associations remained significant even after controlling for neighborhood-level socioeconomic status and individual-level demographics
Conclusion

• Built environment associated with health status and child weight
• Geographic information systems and remote sensing data may inform urban planning approaches to improve health
• Prospective research needed to assess causal effects
Recap 2

• The spatial distribution of high BMI among our patients (at the census tract level) is not random.

• Modifiable aspects of the built environment function as predictors of child weight status.

• Obesity is determined by a complex interplay between genetic, cultural and environmental factors.
Social Environment
(Census and crime data, Survey)

Physical Environment
(GIS variables)

Genetic Endowment
(Parent BMI)

Individual responses:
* TRAVEL PATTERN (GPS tracking)
* Physical Activity & Diet
  (accelerometry, diary, survey)

Health and Function

Obesity (Child BMI)

Health Care (Insurance Status)

Well being

Prosperity
### Food Diary

<table>
<thead>
<tr>
<th>Day</th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Tea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td></td>
<td></td>
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<tr>
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<td>Saturday</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write down everything you eat or drink every day. Don’t forget to include those snacks in between meals!

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**The GPS Navigation Solution**

The estimated ranges to each satellite intersect within a small region when the receiver clock bias is correctly estimated and added to each measured relative range.
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• The Regenstrief Institute: Jane Wang
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