Green Space, Physical Activity and Obesity

Michael Jerrett, PhD

Professor and Chair

Department of

Environmental Health Sciences

University of California, Los Angeles

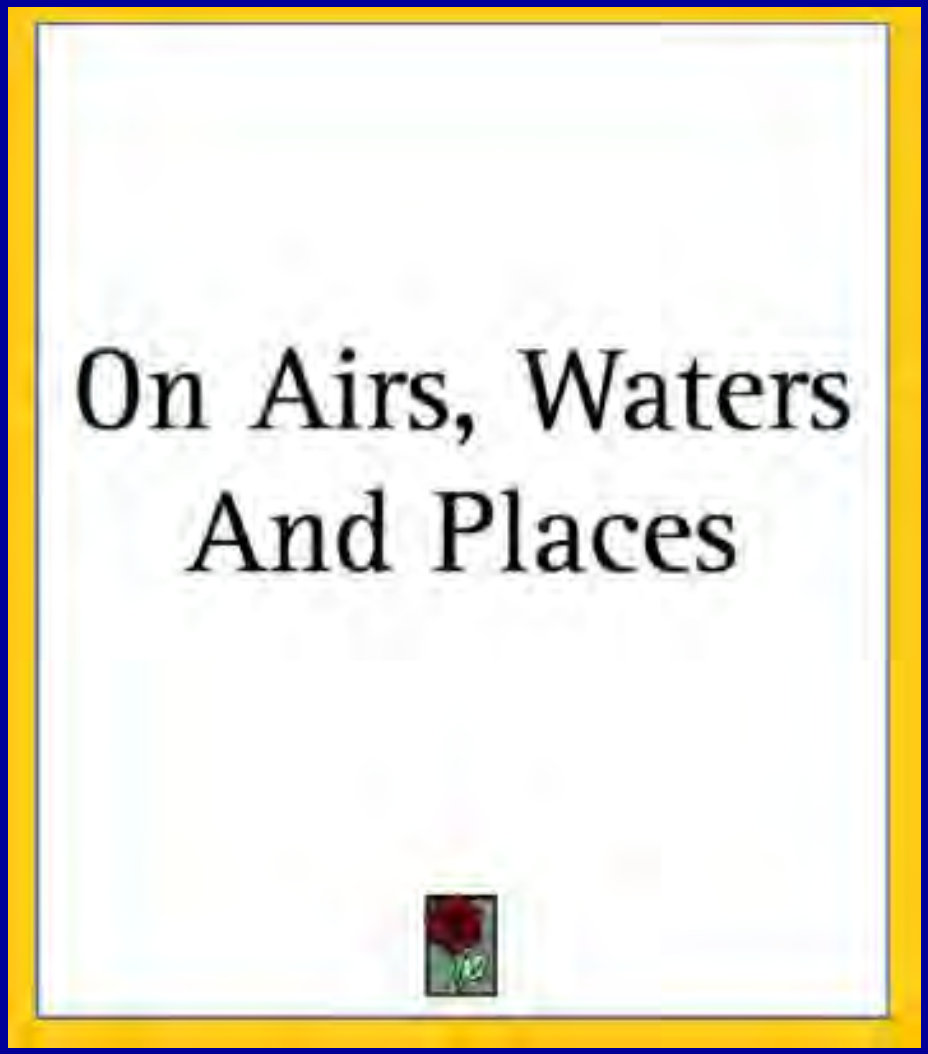
Map of Talk

- Brief historical perspective
- Potential burden of illness large
- Mechanisms linking greenspace to health

Two research study snapshots:

1. Physical activity effects of momentary exposure to greenspace
2. Longitudinal assessment of parks and programming access on obesity development in children

Interest in Places and Health Dates back to Ancient Greece (Hippocrates 460-377 BC)

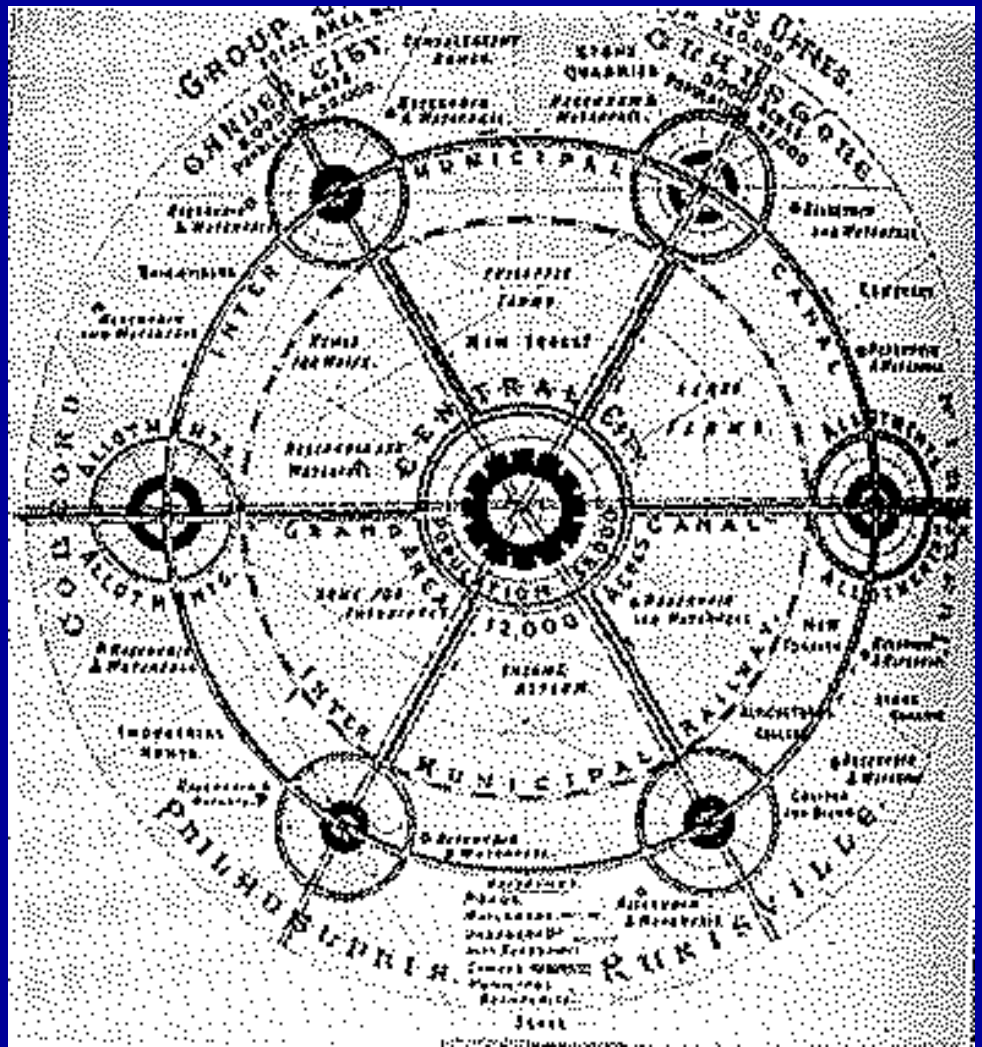


Environmental Squalor of the 19th Century No Green Space

Source:

Hall (1984)

Garden City of To-Morrow 1898-1902 (Howard)



Garden City

Freedom and Health away from Industry

Historically . . .

- Idea that green space exposure would benefit health is nothing new, BUT

- We now have scientific evidence that it might have real effects on major causes of illness and mortality

Physical inactivity has been identified as the **fourth leading risk factor** for global mortality causing an estimated 3.2 million deaths globally (WHO, 2016)

Physical activity reduces the risk of

- cardiovascular diseases
- diabetes
- colon and breast cancer
- depression
- decrease the risk of fractures
- help control weight

Photo credit: © World Obesity

PHYSICAL ACTIVITY (18-64 YEARS OLD)

Per week:

- at least 150 minutes of moderate-intensity aerobic physical activity,

or

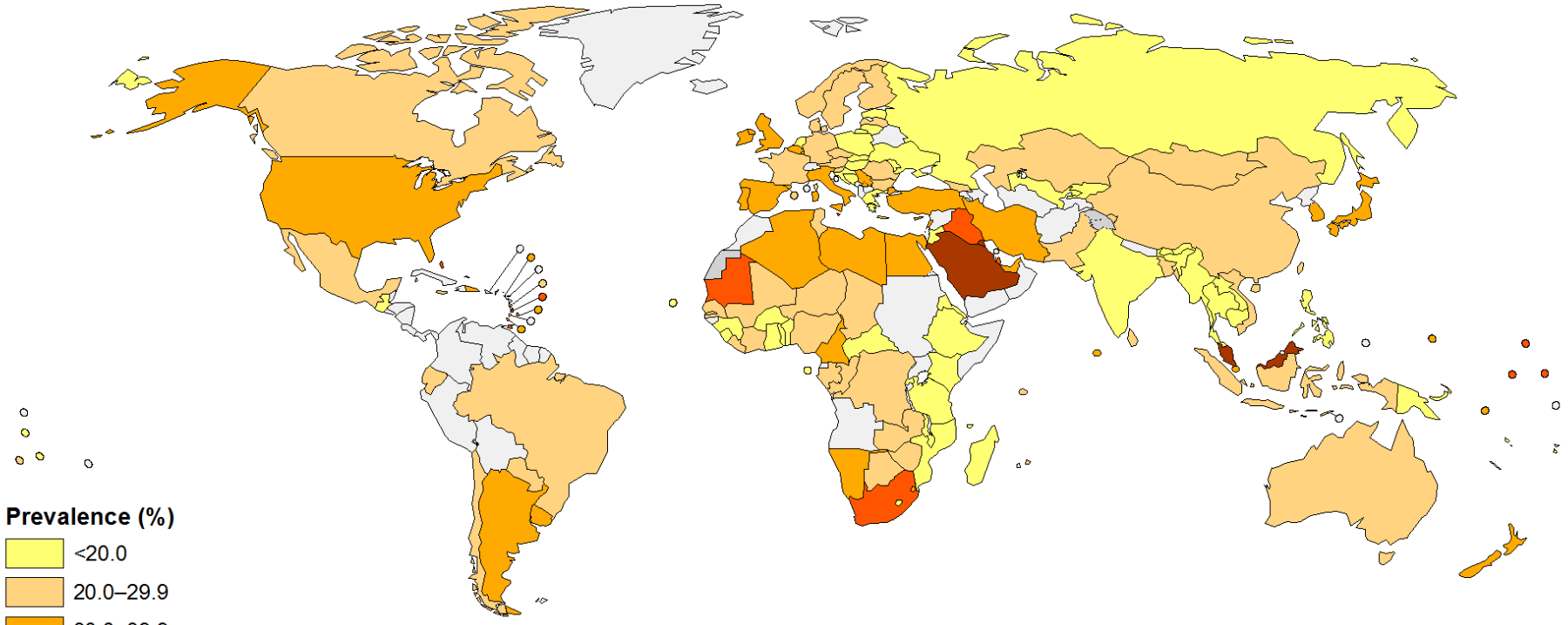
- at least 75 minutes of vigorous-intensity aerobic physical activity

Aerobic activity should be performed in bouts of at least 10 minutes duration.

Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.

Photo credit:
Rudd Center for Food Policy & Obesity

Prevalence of physical inactivity* among adults, ages 18+ (age standardised estimates)
Both sexes



Prevalence (%)

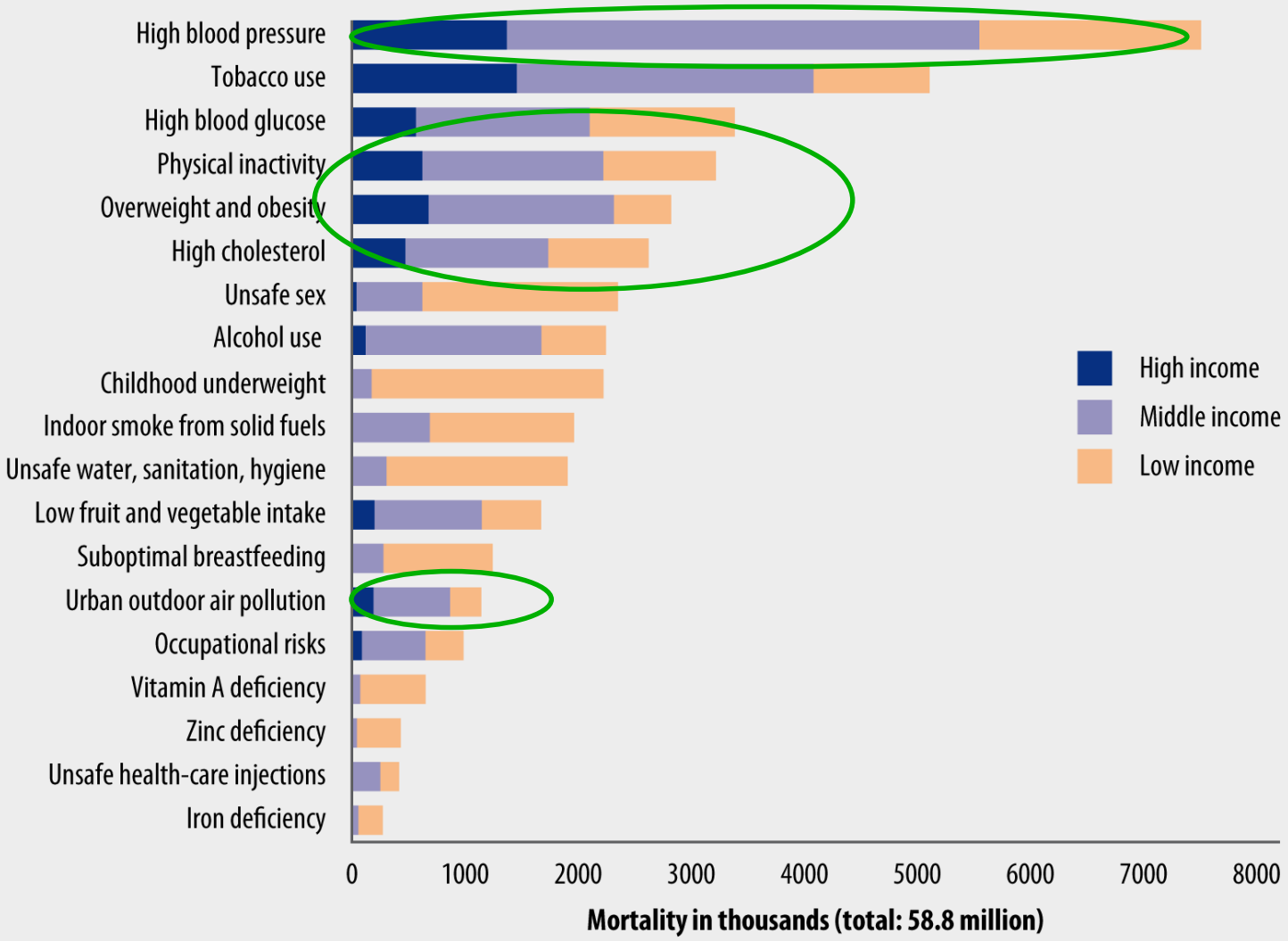
- <20.0
- 20.0–29.9
- 30.0–39.9
- 40.0–49.9
- ≥50.0
- Data not available
- Not applicable

* Less than 150 minutes of moderate-intensity physical activity per week, or less than 75 minutes of vigorous-intensity physical activity per week, or equivalent

Data Source: World Health Organization
Map Production: Health Statistics and Information Systems (HSI)
World Health Organization

World Health Organization

WHO Global Burden of Mortality



Implications

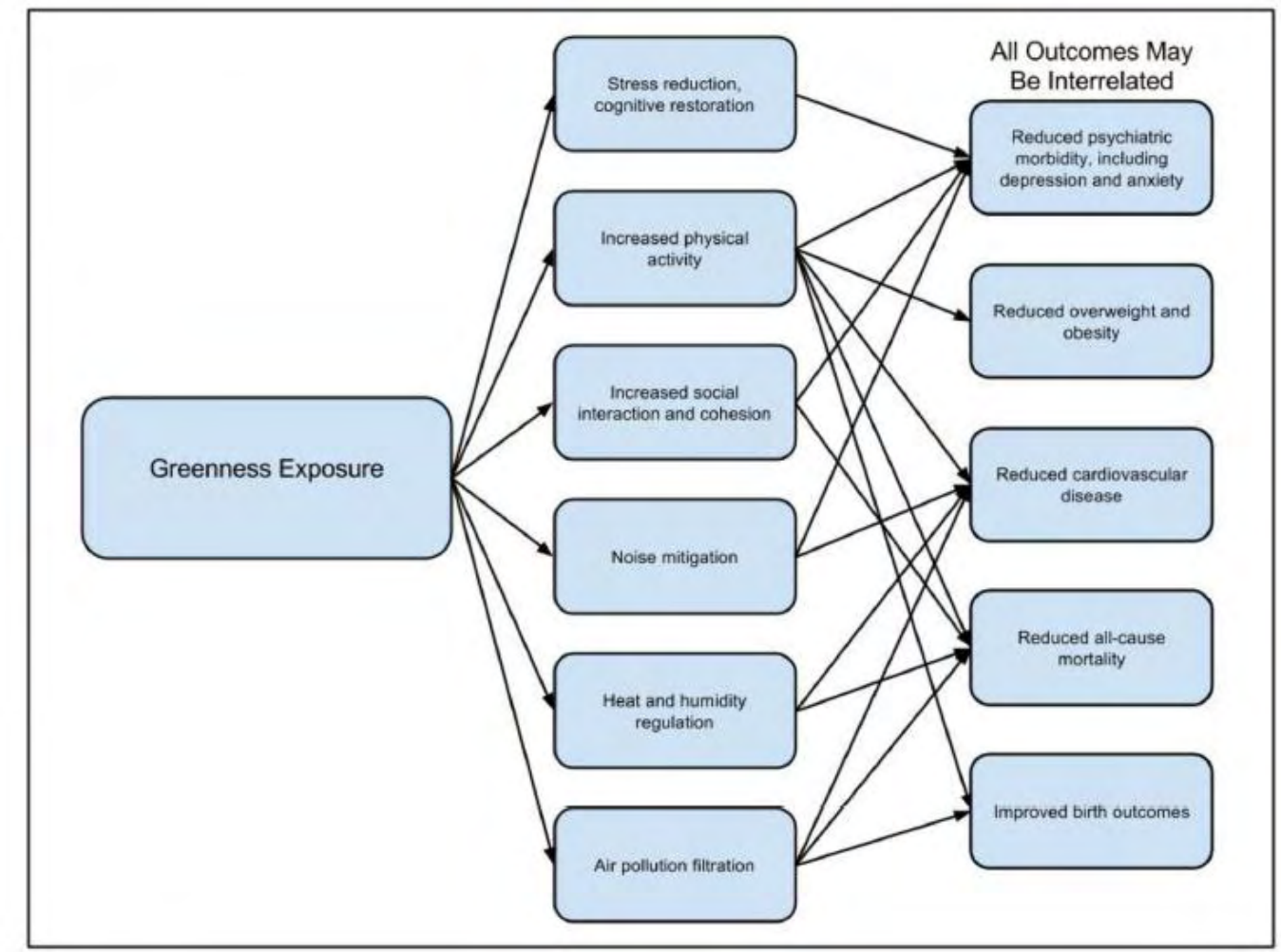
- Physical activity and obesity play a major role in the global burden of mortality
- Even small improvements in physical activity, obesity and possibly stress could have substantial benefits for global health
- Green Space may therefore be a large determinant of health because it links to these important outcomes

USC UNIVERSITY OF SOUTHERN CALIFORNIA

TREC Transdisciplinary Research on Energetics and Cancer Centers

Berkeley University of California

PA Key to Many Health Effects



Direct Health Benefits

The health benefits of urban green spaces: a review of the evidence

A.C.K. Lee, R. Maheswaran

Section of Public Health, School of Health and Related Research, The University of Sheffield, Sheffield S1 4DA, UK
Address correspondence to Andrew Lee, E-mail: andrewlee@shef.ac.uk

USC UNIVERSITY OF SOUTHERN CALIFORNIA

TREC Transdisciplinary Research on Energetics and Cancer Centers

Berkeley University of California

Bottom Line

Whilst there is some evidence and expert consensus to suggest that green spaces can facilitate physical activity, the evidence of a direct effect at present remains weak.[60] However, the available evidence does on balance suggest a positive association between green spaces and better health.

- Interesting results, but many open questions about confounding and who is affected

USC UNIVERSITY OF SOUTHERN CALIFORNIA

TREC Transdisciplinary Research on Energetics and Cancer Centers

Berkeley University of California

A study of community design, greenness, and physical activity in children using satellite, GPS and accelerometer data

Michael Jerrett, PhD

Berkeley
University of California

USC

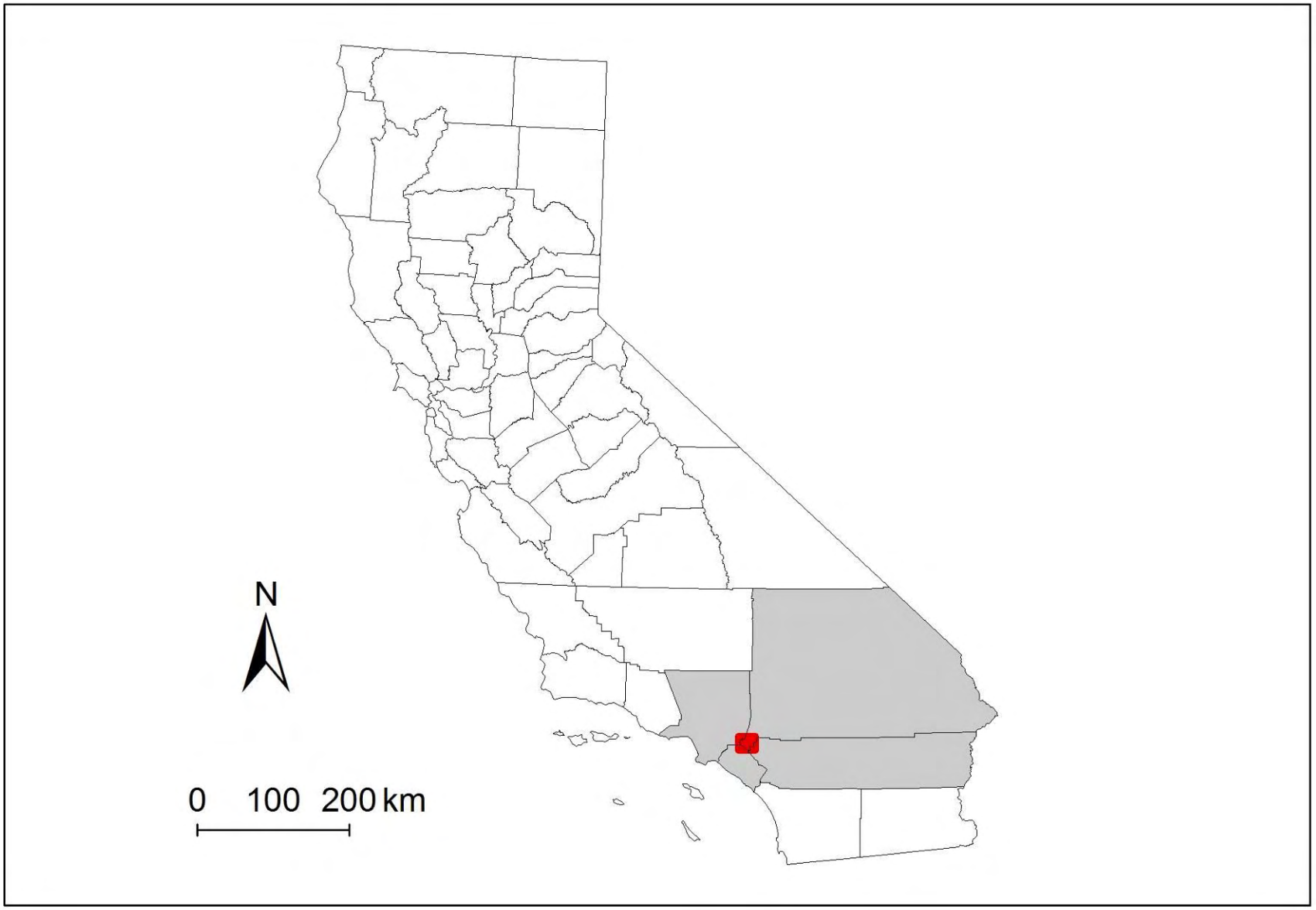
Healthy PLACES* Study
Chino, California

Natural experiment intervention study designed to evaluate the effects of smart growth community design on family obesity risk (e.g. physical activity behavior)

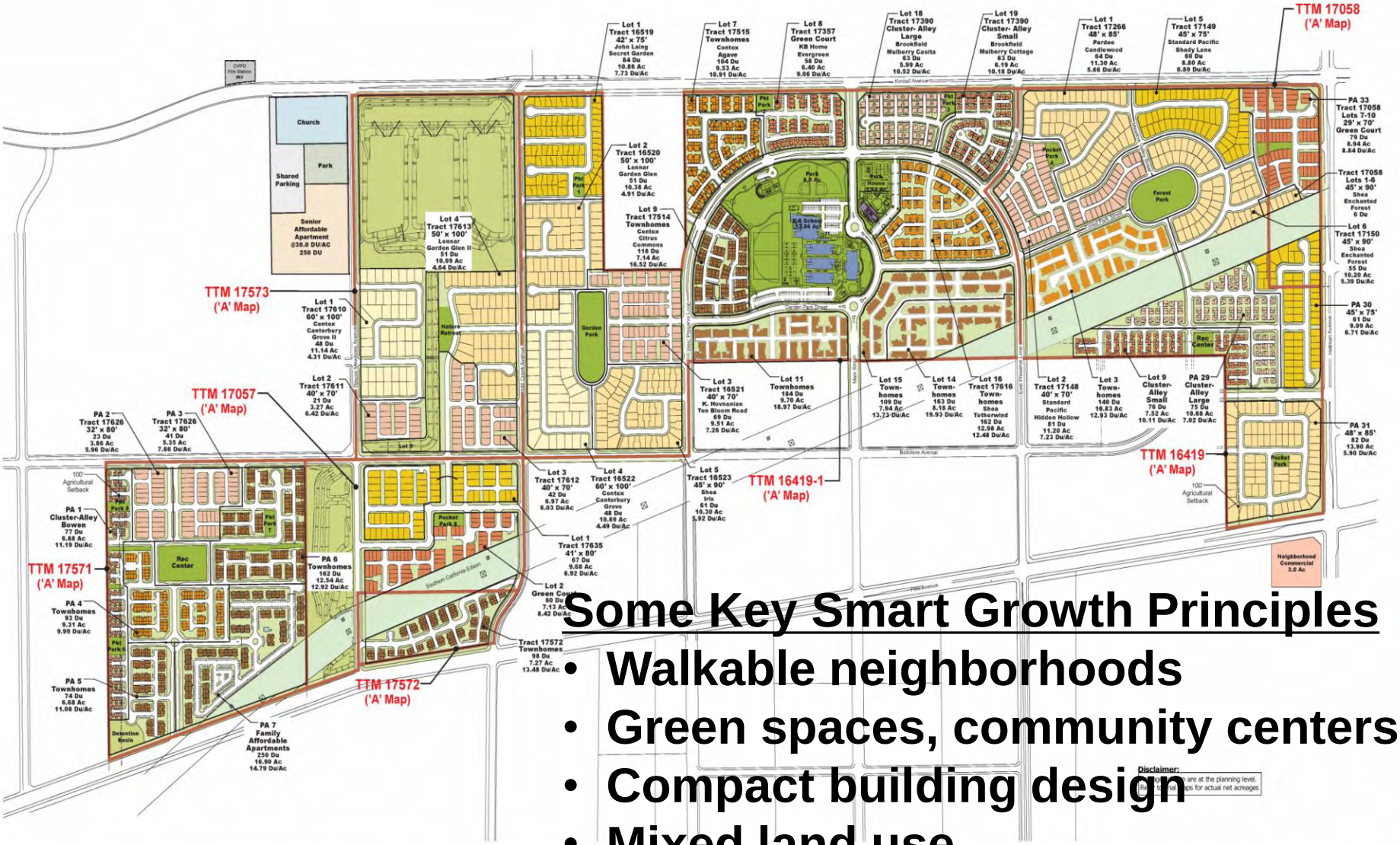
- Intervention group: smart growth residents **(~1/3**)
- Comparison group: community controls from nearby conventional communities and from random controls **(~2/3**)
- Anthropometric, accelerometer and GPS data
- Longitudinal: data collected annually for 4 years
- **386 families** at baseline for year 1 (1 parent and 1 child each)

**** Promoting Livable Active Community EnvironmentS***

Healthy PLACES Study Area
Chino, California



The Preserve Community Plan



Some Key Smart Growth Principles

- Walkable neighborhoods
- Green spaces, community centers
- Compact building design
- Mixed land use

Current Study

- **Is neighborhood greenness exposure associated with heightened physical activity in children?**

- **If so, is the association stronger for children residing in a smart growth community?**

Space-Time-Activity Data Collection

GPS and Accelerometer (ACC) Monitoring Devices

GPS Logger GlobalSat BT 335

- Date & Time
- Location (Latitude, Longitude)
- Speed

Accelerometer ActiGraph GT2M

- Date & Time
- Activity Counts (index for activity)

GPS-ACC collected every 30 seconds for 7 days (except when bathing, swimming, or sleeping)

Merging Results Example Data (selected fields)

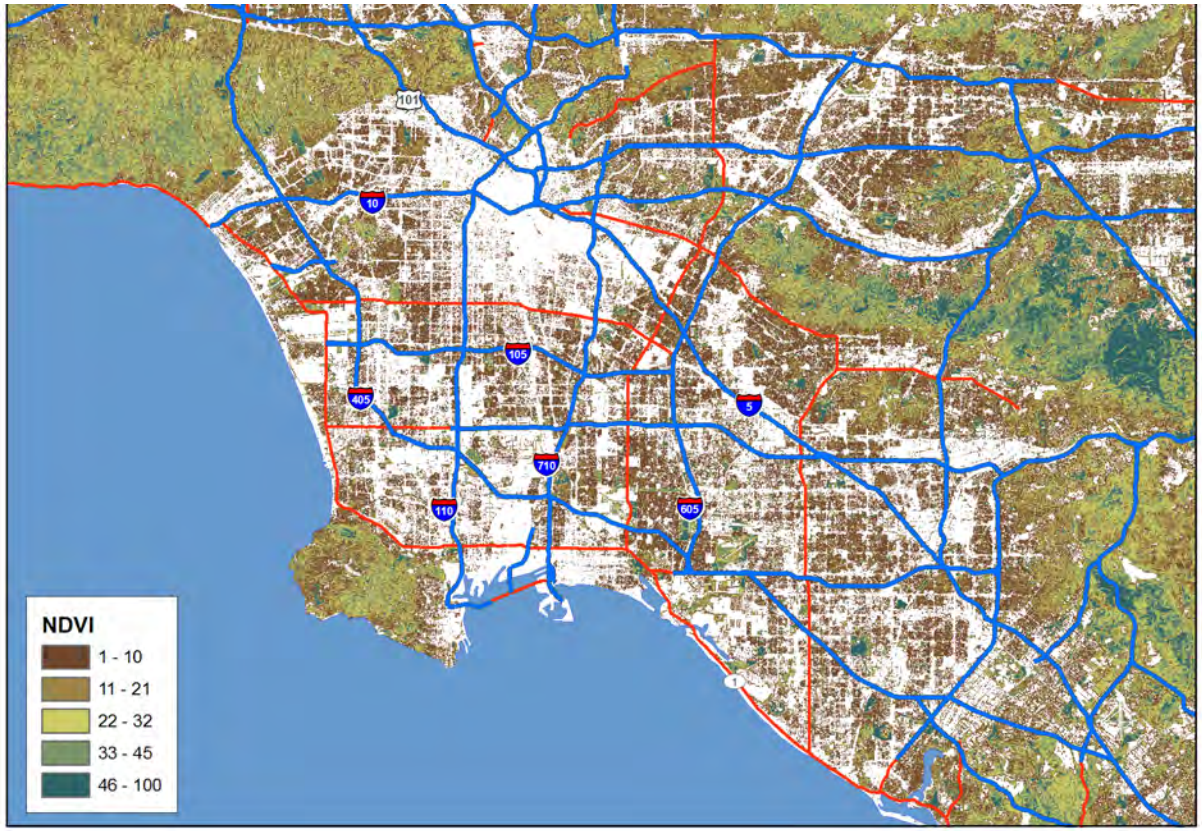
SID	Female	Age	Race	Community	Time	Lat	Long	Speed	MVPA
12345	1	10	Hispanic	1	85.19479	34.xxxx	-117.xxxx	0.3	0
12345	1	10	Hispanic	1	85.19514	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19549	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19583	34.xxxx	-117.xxxx	0.3	0
12345	1	10	Hispanic	1	85.19618	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19653	NA	NA	NA	1
12345	1	10	Hispanic	1	85.19688	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19722	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19757	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19792	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19826	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19861	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19896	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19931	34.xxxx	-117.xxxx	0.1	0
12345	1	10	Hispanic	1	85.19965	34.xxxx	-117.xxxx	0.6	0
12345	1	10	Hispanic	1	85.2	34.xxxx	-117.xxxx	0.8	1
12345	1	10	Hispanic	1	85.20035	34.xxxx	-117.xxxx	0.4	1
12345	1	10	Hispanic	1	85.20069	34.xxxx	-117.xxxx	0.7	1
12345	1	10	Hispanic	1	85.20104	34.xxxx	-117.xxxx	0.5	1
12345	1	10	Hispanic	1	85.20139	34.xxxx	-117.xxxx	0.9	0
12345	1	10	Hispanic	1	85.20174	34.xxxx	-117.xxxx	0.4	0
12345	1	10	Hispanic	1	85.20208	34.xxxx	-117.xxxx	2.29	1
12345	1	10	Hispanic	1	85.20243	34.xxxx	-117.xxxx	0.7	0
12345	1	10	Hispanic	1	85.20278	34.xxxx	-117.xxxx	0.1	0

Average Number Records per Subject: 21,000

Remote Sensed Indicator of Vegetation

Normalized Difference Vegetation Index

= (NIR - RED) / (NIR +RED)



Assigned NDVI values to 30-second epochs in GIS

Scope of Analysis:
Neighborhood Activity
Outside of Home & Non-School Hours

Neighborhood

500 m buffer

Home Excluded

30m buffer

Motorized Excluded

>32 kph/20mph

Excluded school hours (Aug 31-Jun 10, 9am-2pm)

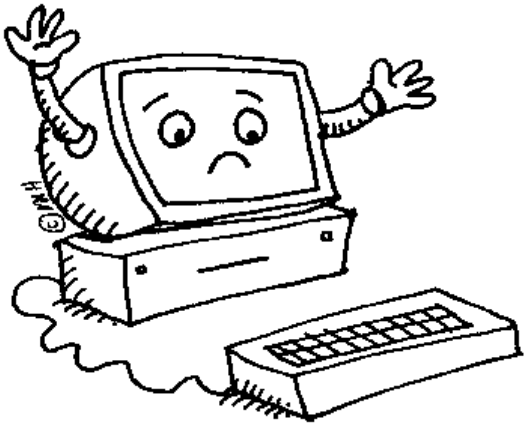
Inclusion Criteria

Invalid Data

- ACC Outliers: Activity > 16383 counts per 30 sec.
- GPS Outliers: GPS speeds > 169kph/105mph
- Night Hours: 11pm-5am
- ACC Non-Wear: > 1 hour continuous zero counts
- Missing Data: Records missing either GPS or ACC

Valid Day

- ≥ 4 hours of **valid** data



Valid Subject

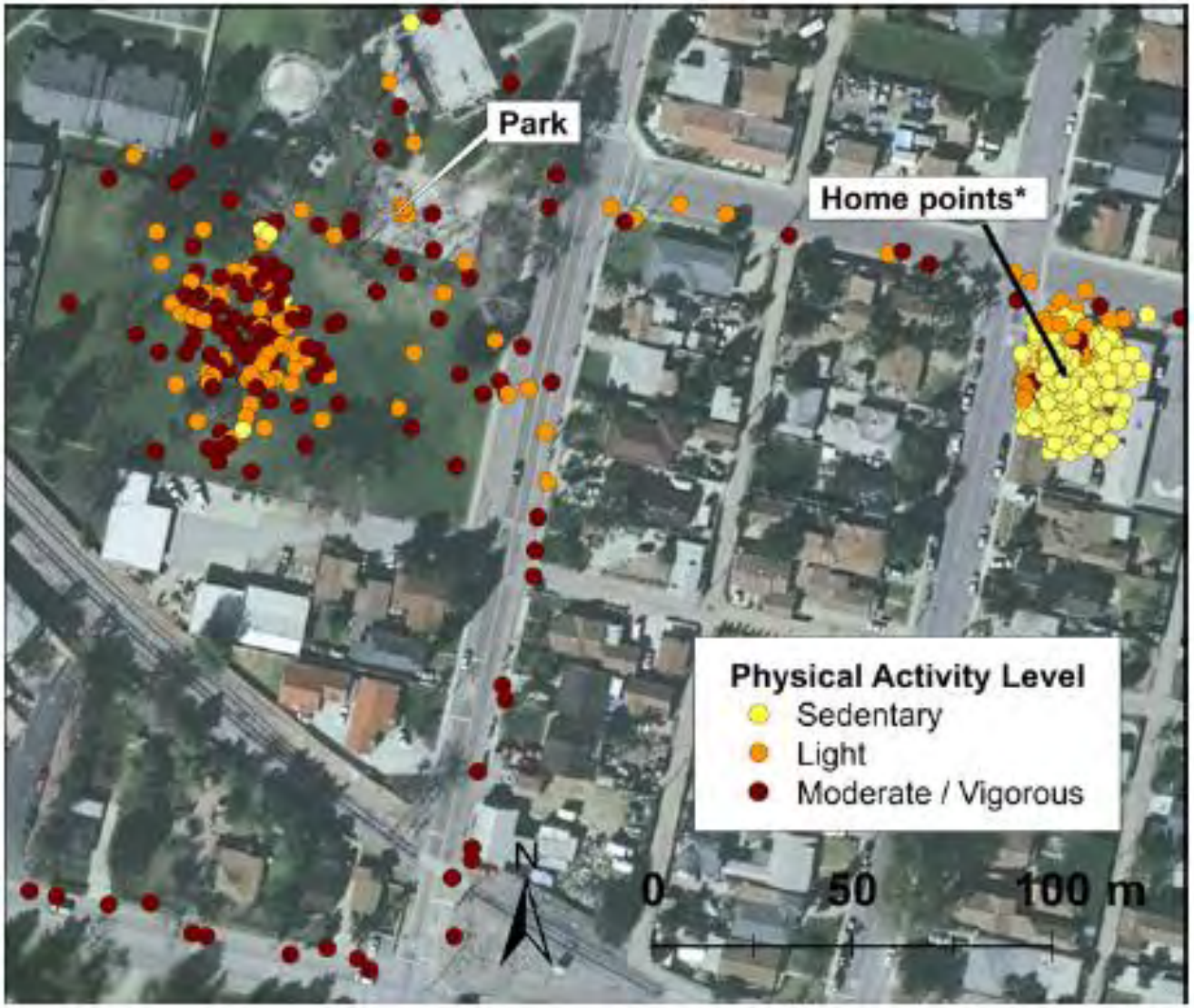
- ≥ 3 valid days

Valid for Neighborhood Analysis

- > 1 hour of neighborhood activity after removal of home, school and motorized data

Final Sample Size 208 subjects, 142,552 records

Activity Pathway for 1 Child



Momentary Greenness Exposure and the Likelihood of MVPA
Logistic Regression with 142,552 30-second epochs from 208 subjects

	Definition	OR (95% CI)	P-value
Response Variable MVPA	0: Sedentary/light 1: Moderate/vigorous		
Covariates **NDVI**[a]	Normalized difference vegetation index	**1.34** (1.30, 1.38)	< **0.001**
Community Design Group	0: Conventional 1: Smart growth	1.26 (0.82, 1.92)	0.29
NDVI*Community	Interaction	**1.044** (1.001, 1.089)	**0.04**

- Negative NDVI values primarily representing water were assigned zero.
  For regression **NDVI values were rescaled by dividing by their 10-90th quantile range**.
- **Controlled for age, gender, race, and income.**
- Other covariates included BMI and a temporal variable that partly adjusted for **seasonality**.
- **Random effect on subject** included to account for repeat measures.
- MVPA kernel density term (bandwidth 100m) included to **address potential autocorrelation.**
- Moran's I test for spatial autocorrelation was significant for model residuals. However the magnitude was small (**Moran's I=0.09**) indicating the effect of autocorrelation on parameter and standard error estimation was likely minimal.

Conclusions

- Results indicate greenness was positively associated with children's momentary physical activity
- Methods using traditional buffers showed no effect but exposure measurement error reduced with this analysis
- Although these results suggested modest effect sizes, the health impacts could be cumulatively substantial at the population-level
- Findings also suggest the greenness-physical activity association was stronger for residents from the smart growth community compared to conventional communities


Future Steps

- Future studies will include other spatial layers (e.g. park) and exposures such as traffic, air pollution, temperature
- Longitudinal analyses of obesity and physical activity
- Use of new cell phone based censors


Health & Place 18 (2012) 46–54

Contents lists available at SciVerse ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

A study of community design, greenness, and physical activity in children using satellite, GPS and accelerometer data

Estela Almanza[a,*], Michael Jerrett[a], Genevieve Dunton[b], Edmund Seto[a], Mary Ann Pentz[b]

[a]*Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, Berkeley, CA 94720-7360, USA*
[b]*Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA 90089-9031, USA*

DOI: 10.1016/j.healthplace.2011.09.003.

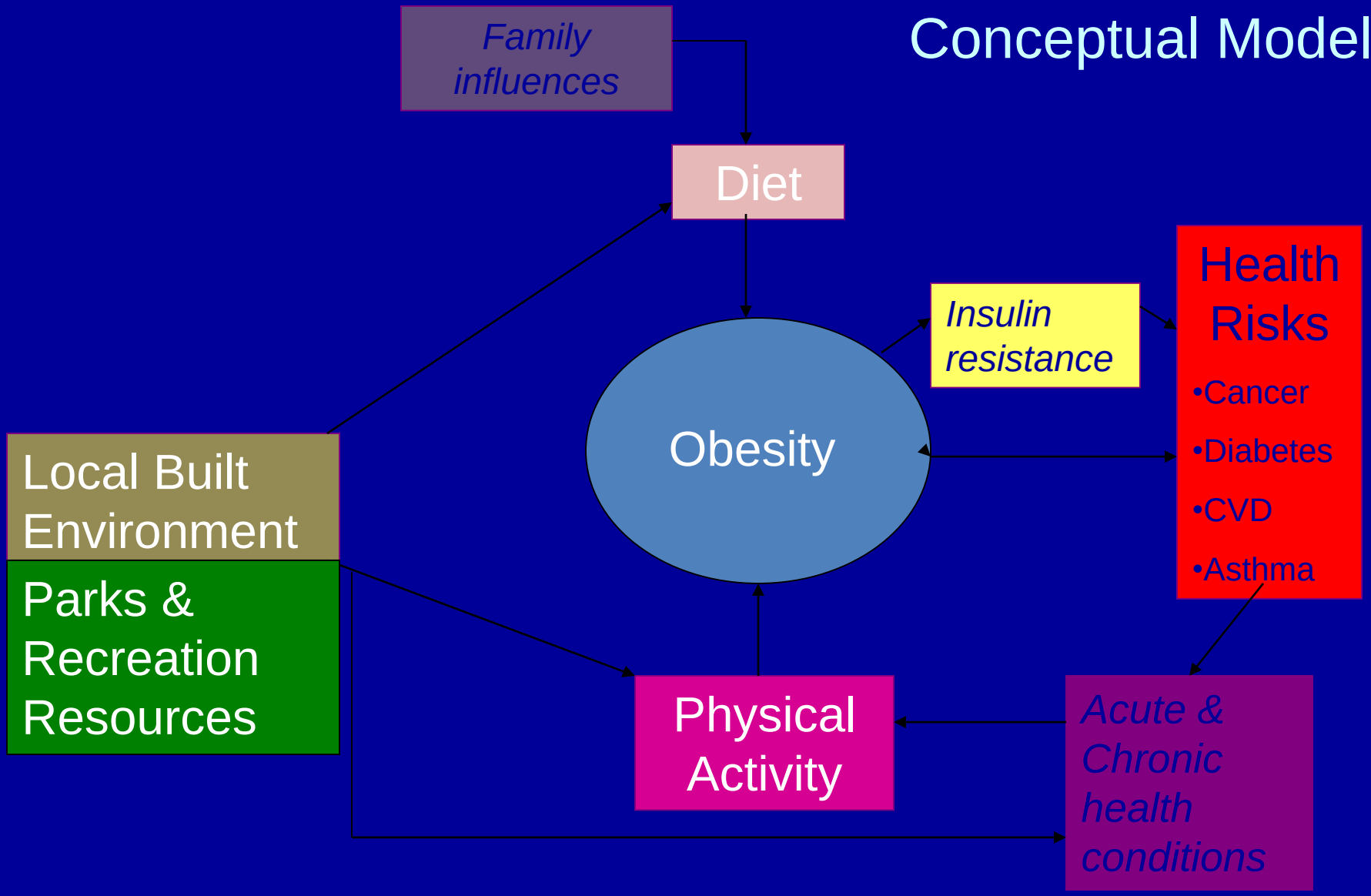
Access to Parks/ Programming and Obesity Development in Children

Research Aim

- To assess the association between parks/ recreational programming access and the longitudinal development of measured BMI (Kg/m^2) in children aged 10-18 years

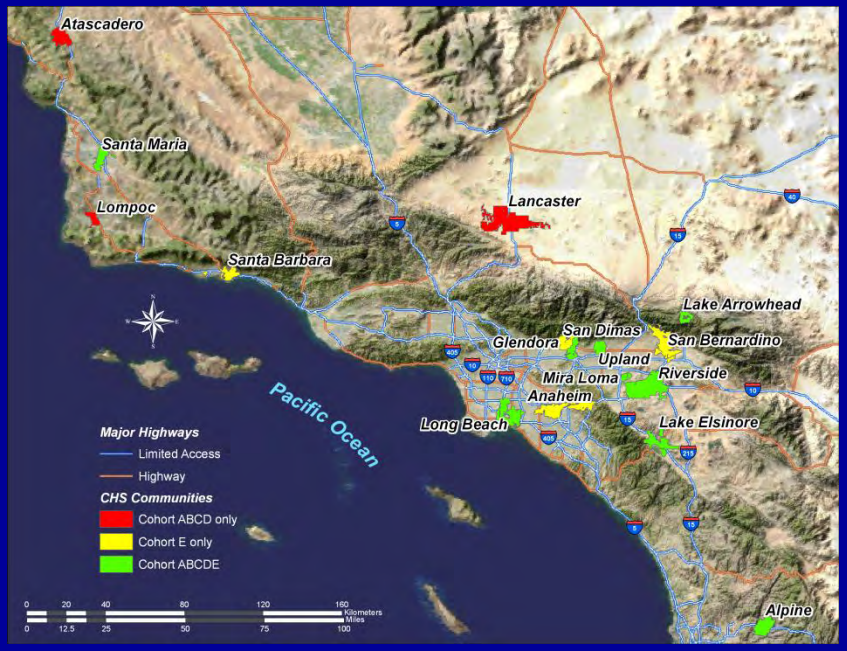
- Children's Health Study (CHS) offers longitudinal sample with objectively measured BMI data

Conceptual Model

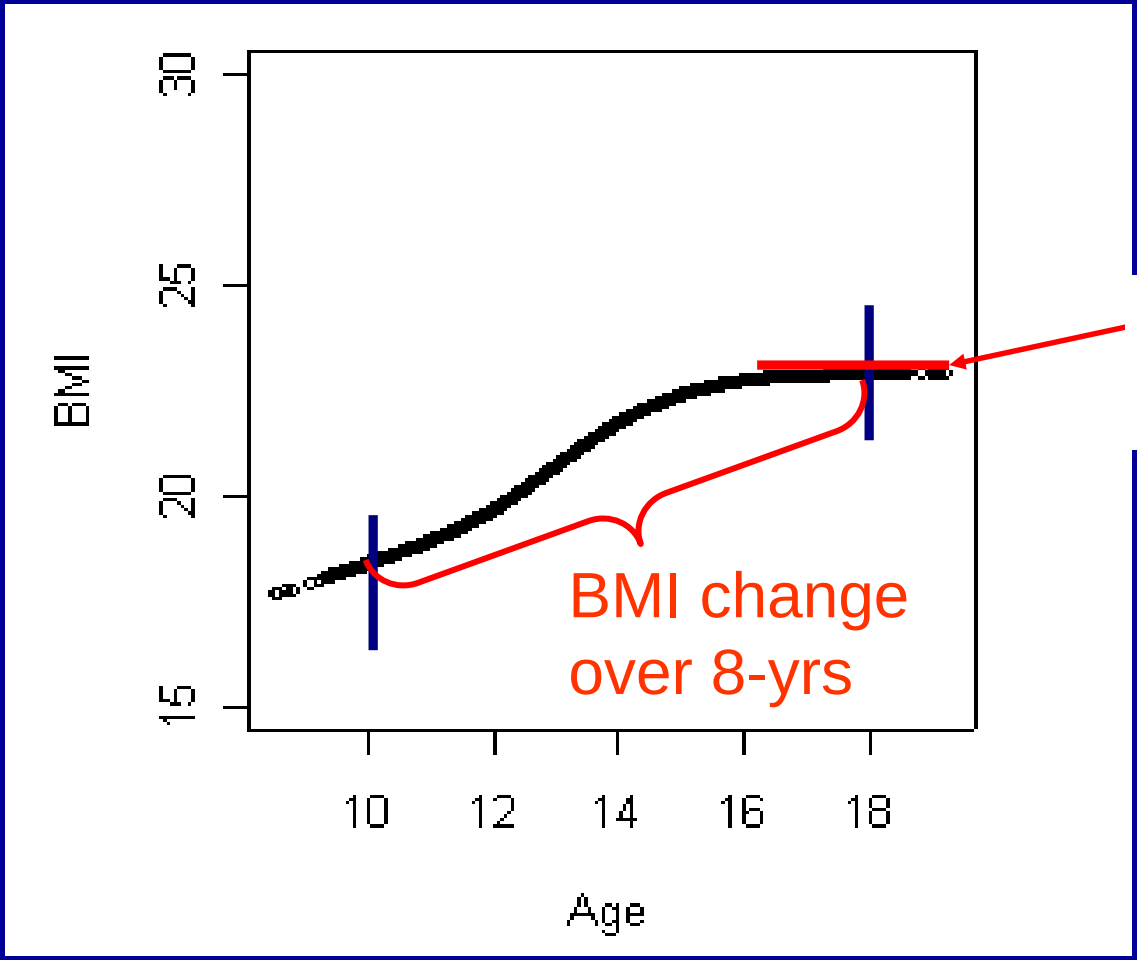


Data and Methods

- 11,797 CHS children
  - Up to 8 years of follow up
  - Building on $50+ million prior investment
  - 12 Southern California communities
  - BMI measured yearly by trained staff
- Geospatial data
  - Land use
  - Transportation
  - Business locations
  - Public facilities/programs
  - Green cover
  - Air pollution
- Use of flexible growth curve multilevel modeling



Models Focus on *Attained BMI at Age 18*

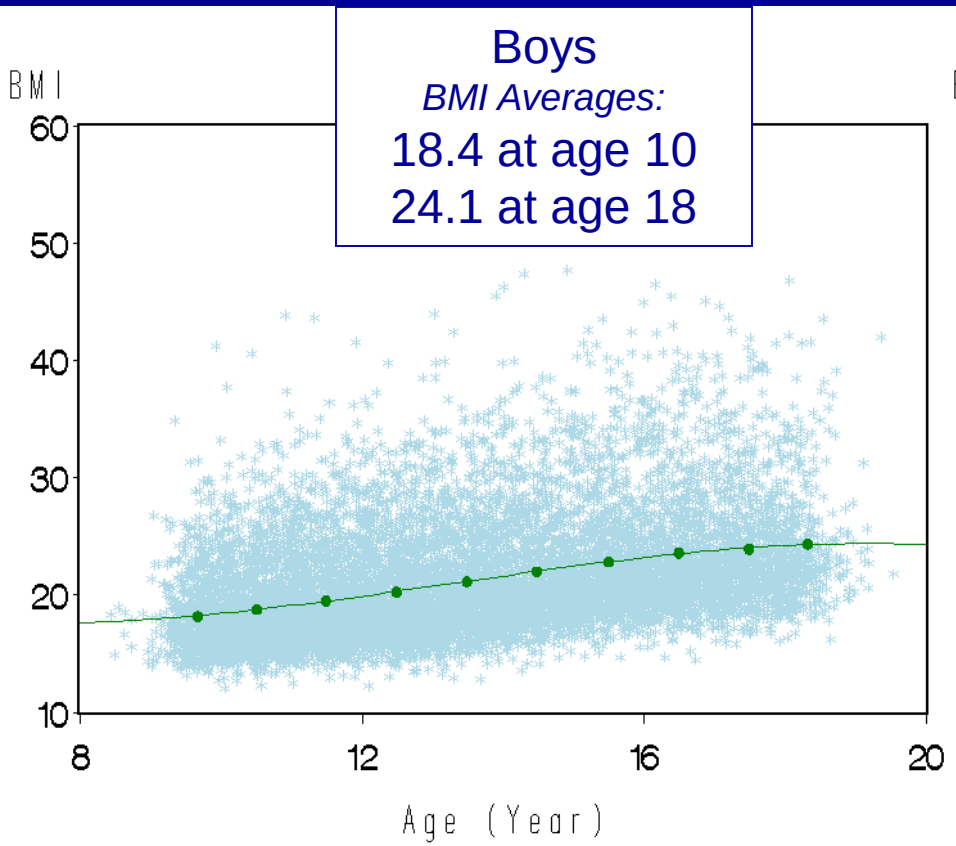


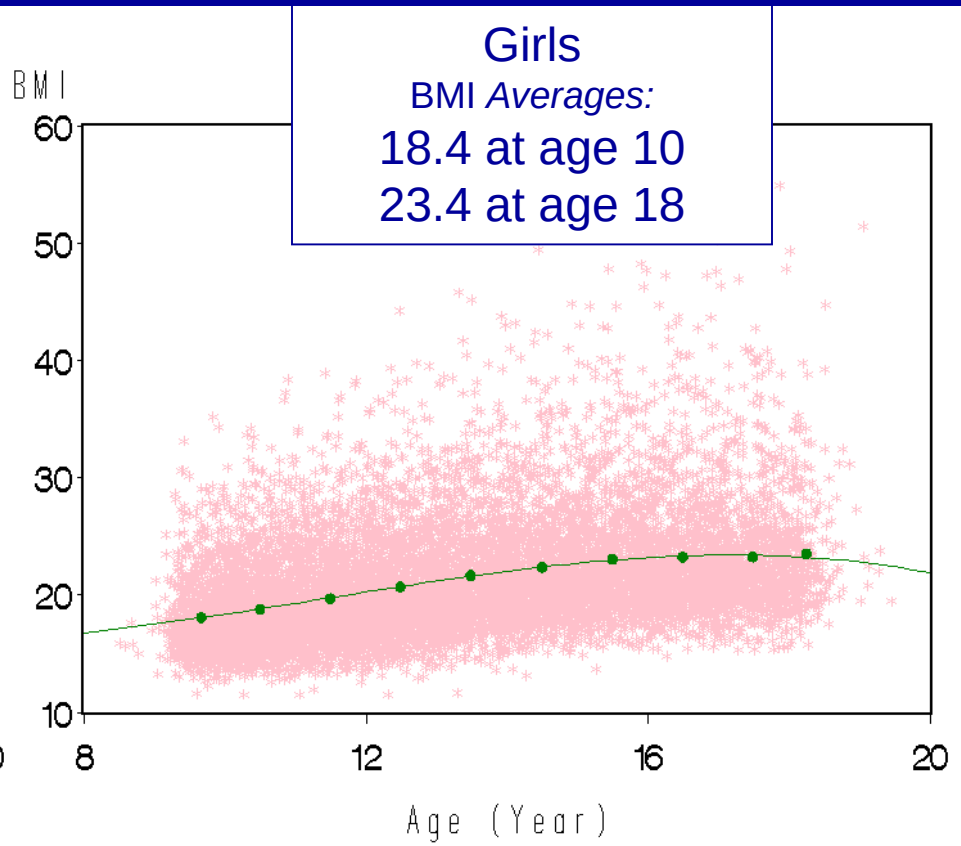
Characteristics of Analytic Cohort Age 10-18

Cohort (year, # of subjects)	**Prevalence Rate (%) of overweight (BMI ≥ 85th %ile)**				
	All	Ethnicity			
		Non-Hispanic White	Hispanic	African American	Asian
(1993: 2192)	25.3	21.6	36.0	20.2	15.9
(1996: 2081)	27.5	24.0	34.5	31.0	21.6

Analytic Cohort N = 3318 with 8 years of follow up from ages 10-18

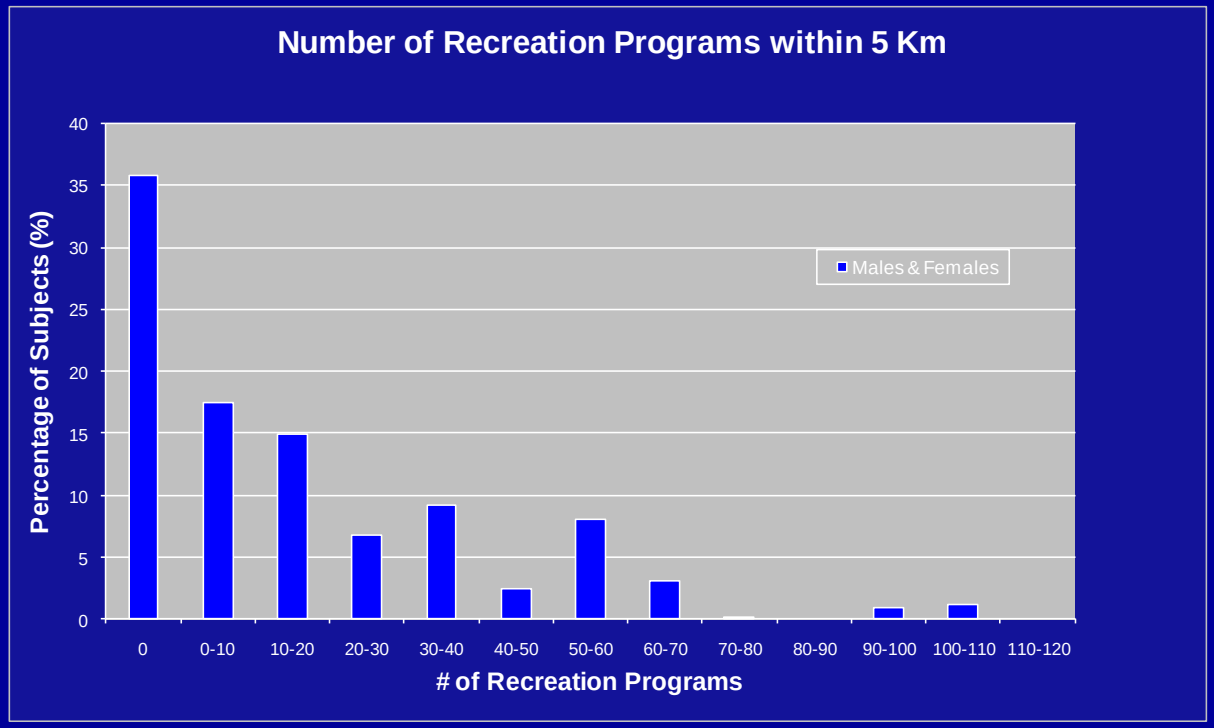
BMI Growth Over 8 Years

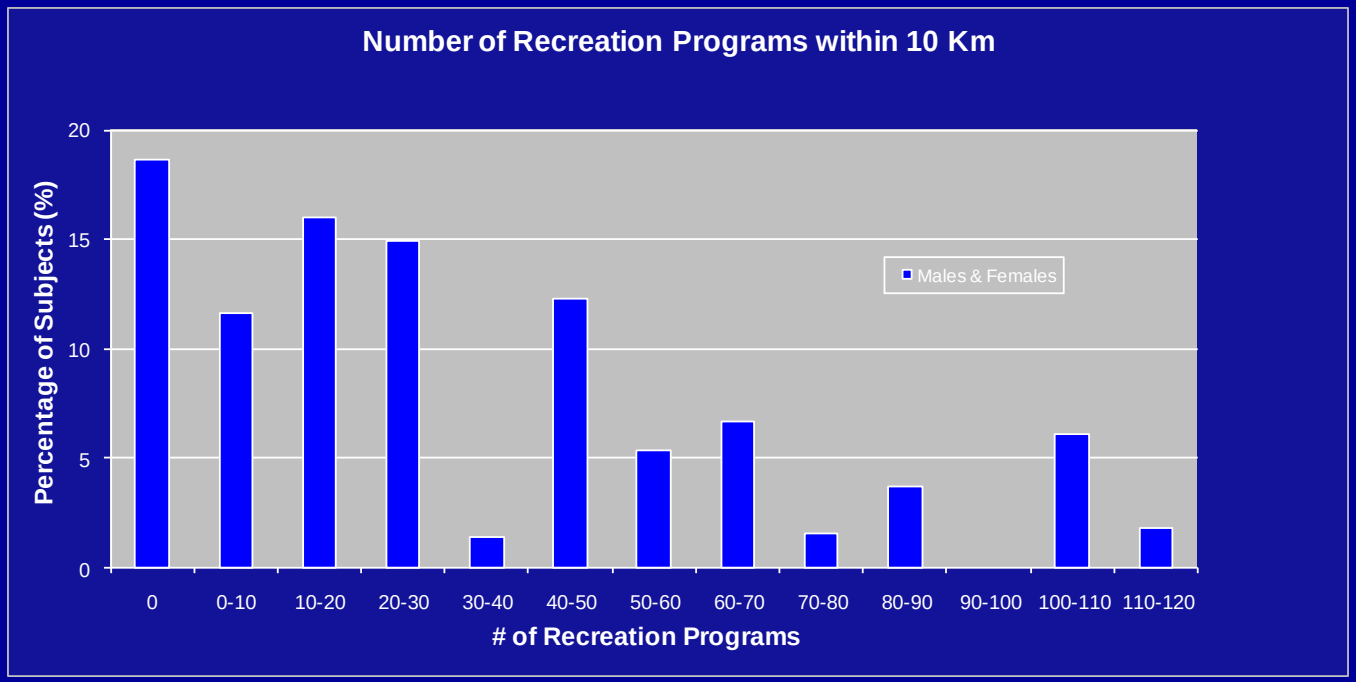




Obesity Society Conference

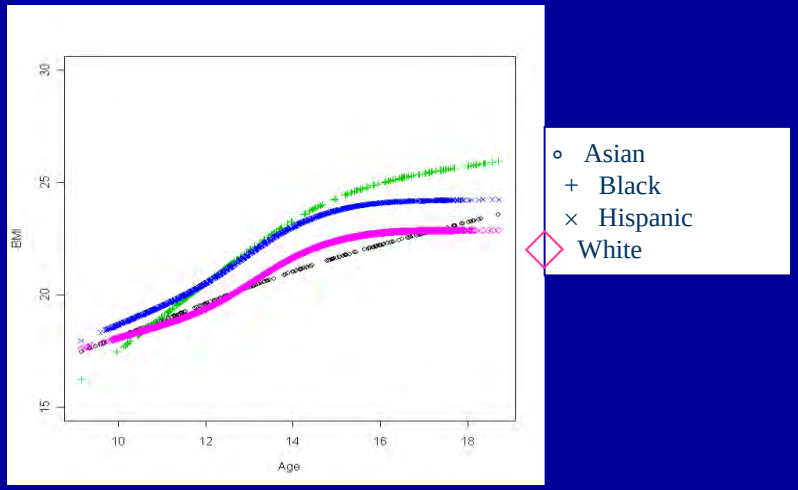
Access to Recreation Programs





Multilevel Modeling of BMI Trajectories

Level 1: Within subject/between times

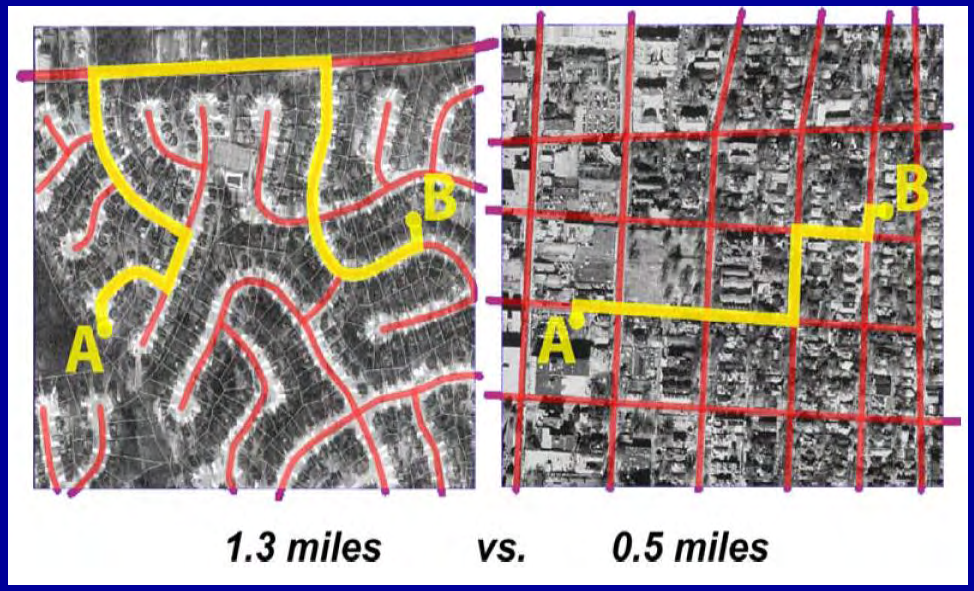


Allows for:

- Prediction of attained BMI levels for each subject at any age
- Calculation of 8-yr BMI growth slope for each child
- Adjustment of time-dependent covariates (e.g., health status)
- Non-linear growth trajectory due to puberty

Obesity Society Conference

Level 2: Between subjects/within community



Allows for:

- Within-community built environment effects
- Community average of 8-yr BMI growth
- Adjustment of time-independent covariates (e.g., ethnicity)
- Control of individual-level errors

Obesity Society Conference

Level 3: Between communities

Allows for:

- Between-community pollution effect, urban sprawl, crime
- Adjustment of ecologic covariates

Obesity Society

Conference

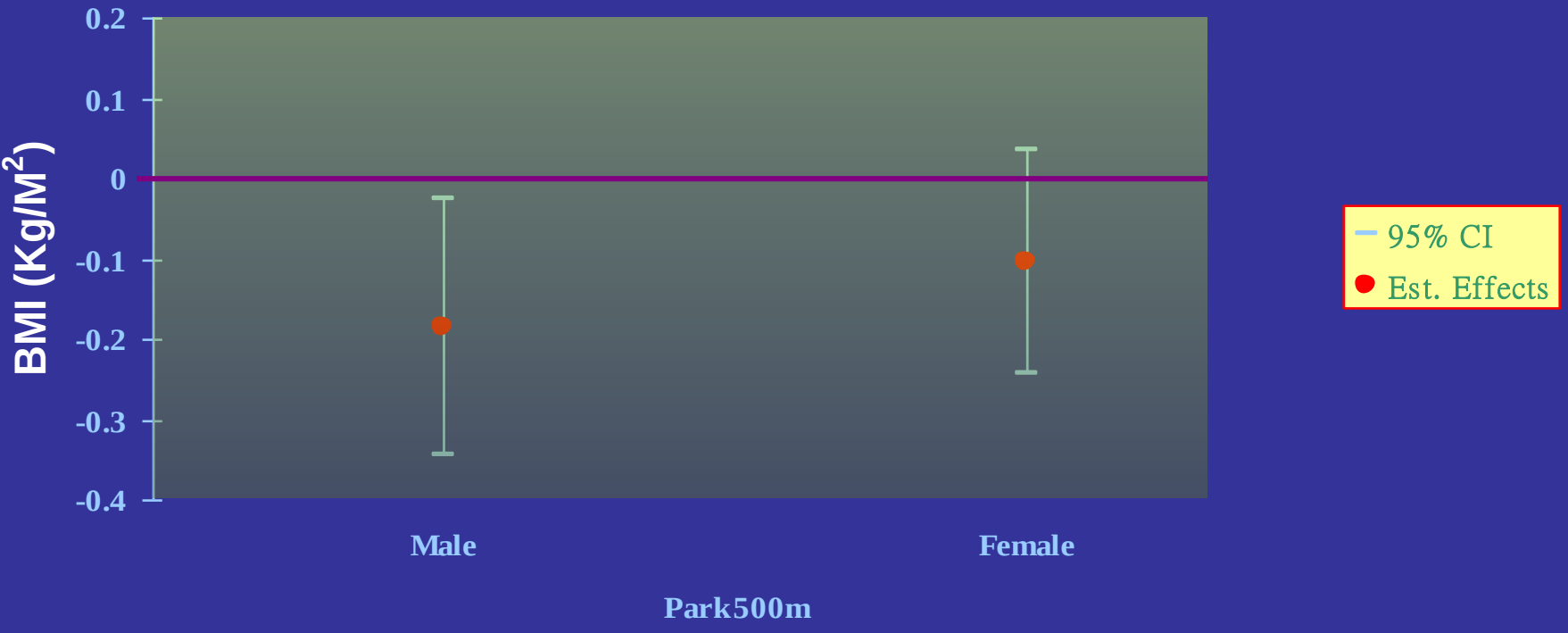
Model Results (8-year Growth Curves, Age Centered at 18, with adjustments for ethnicity, town, gender, cohort, and park/recreation specific confounders)

Variable of Interest	Effect: Males (std)	Effect: Females (std)
Park space (km) within 500 meter buffer	-0.012*** (0.005)	-0.007* (0.005)
Recreation programs within 5 km buffer	-0.015*** (0.004)	-0.008*** (0.004)
Recreation programs within 10 km buffer	-0.025*** (0.005)	-0.016*** (0.005)

Model Confounders

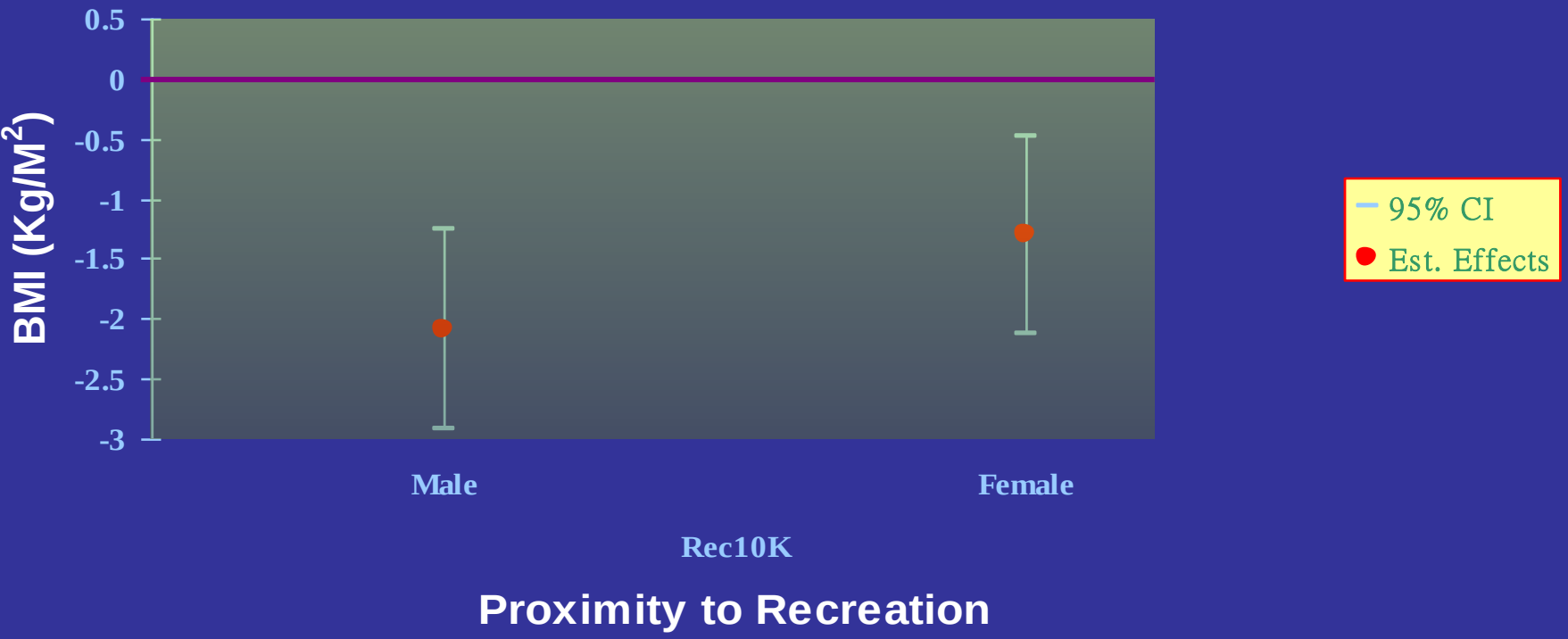
	Major Outcomes		
	Parkland within 500 m	Total Number of Recreation Programs within 5 KM	Total Number of Recreation Programs within 10 KM
Traffic Density within 150 m Buffer	√	√	√
Traffic Density within 300 m Buffer	√	√	
Distance from Residence to Nearest Side of Highway		√	√
NDVI within 500 m Buffer	√	√	√
Buffer Population (Total Population within 500 m Buffer)		√	√
Average Urban Impreviousness within 500 m Buffer	√	√	√
Average Tree Canopy within 500 m Buffer		√	√
Total Length of Highway within 500 m Buffer		√	
Total Length of Major Arterial within 500 m Buffer	√	√	
Total Length of Airport Runway within 500 m Buffer			√
Agriculture Land Use within 500 m Buffer			√
Average Block Size of Blocks within 500 m Buffer		√	
Number of “X” Intersections within 500 m Buffer	√	√	√
Percent Below Poverty within Census Block	√	√	√
Percent Unemployment within Census Block		√	
Town Level Forcible Rape Rate			√

Proximity of Parks & BMI Level at Age 18 (10%-90%ile Scale)



Obesity Society Conference

Proximity of Recreation & BMI Level at Age 18 (10%-90%ile Scale)



Obesity Society Conference

Results Summary

- Park space within 500 m of child's home inversely associated with BMI at age 18
- Public recreational programs ≤10 km of child's home also protective for obesity **with large effects**
- Many children have poor access to public recreational programs
  - *Almost 20% have no access within 10 km*
  - *36% have no access within 5 km*

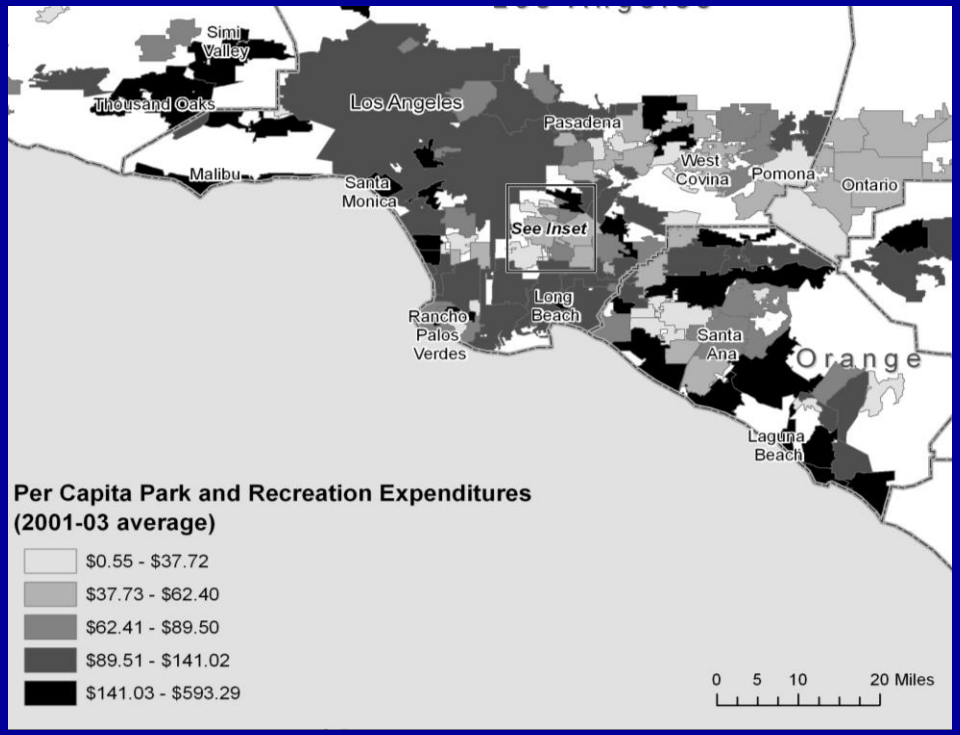
Interpretation of Findings for Recreational Programs and BMI

- If all children had comparable access to recreational programs:
  - ***Boys:*** *11.26% move from overweight to normal; 3% from obese to overweight*
  - ***Girls:*** *8.5% move from overweight to normal; almost 3% from obese to overweight*

Obesity Society Conference

Connections to Active Living Interventions

- Increase park space and recreational programming near poor and minority neighborhoods with high densities of children



Obesity Society Conference

Research Team

- Jennifer Wolch, PhD, Co-I (UCB)
- Michael Jerrett, PhD, PI (UCB)
- Kiros Berhane, PhD, PI (USC)
- Rob McConnell, MD, Co-I (USC)
- Frank Gilliland, MD, PhD, Co-I (USC)
- Kim Reynolds, PhD, Co-I (USC)
- John Wilson, PhD, Co-I (USC)
- Chih-Chieh Chang, PhD Student (USC Biostatistics)
- Claudia Lam, PhD Student (USC Biostatistics)
- Julienne Gard, PhD Student (USC Geography)
- Bernardo Beckerman PhD Student (UCB Public Health, GIS)
- Zev Ross, Consultant (GIS, Land Use Regression)
- Kirby Brady, MPl Student (USC Planning)
- Funding NCI, RWJF

Better physiological effects of exercise when in greenspace compared to other areas

- Small but interesting body of literature from crossover experiments
- Subjects exercised in controlled or non-green settings
- Several studies show improved mental health outcomes