Automobile Traffic Around the Home and Development of Obesity in Children: A Longitudinal Cohort Study

Michael Jerrett, PhD

School of Public Health

University of California, Berkeley

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Research Team

- **Kiros Berhane, PhD, PI (USC)**
- **Jennifer Wolch, PhD, Co-I (USC)**
- **Rob McConnell, MD, Co-I (USC)**
- **Kim Reynolds, PhD, Co-I (CGU)**
- **Frank Gilliland, MD, PhD, Co-I (USC)**
- **John Wilson, PhD, Co-I (USC)**

- **Chih-Chieh (Roger) Chang, PhD Student (USC Biostatistics)**
- **Bernie Beckerman, MS Student (UCB Public Health)**
- **Claudia Lam, PhD Student (USC Biostatistics)**
- **Julienne Gard, PhD Student (USC Geography)**
- **Kirby Brady, MPl Student (USC Planning)**
- **Fred Lurmann, MS, Exposure Consultant, Sonoma Technology**
- **Zev Ross, MS, GIS Consultant**

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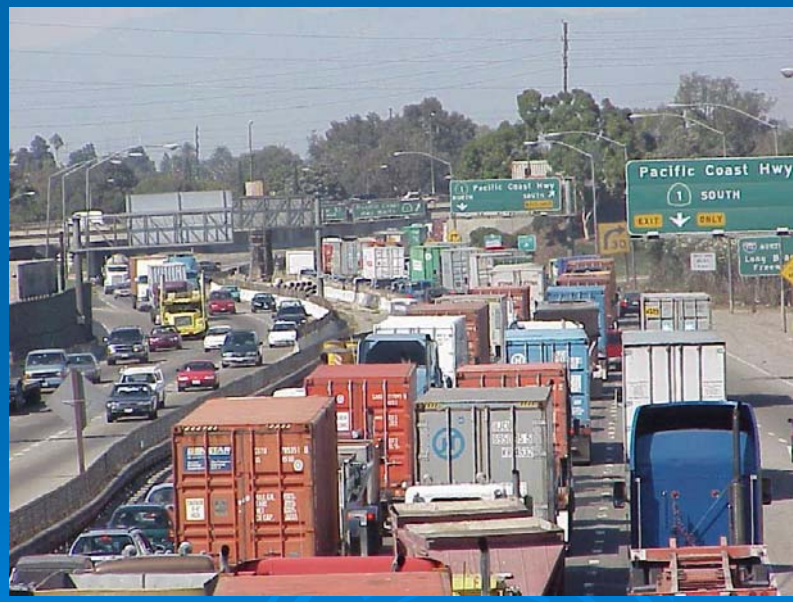
Background

- Growing evidence links built environment to obesity
- Suggestion of associations between density, connectivity, land use mix, recreation access, safety and obesity in children (N = 22 studies)



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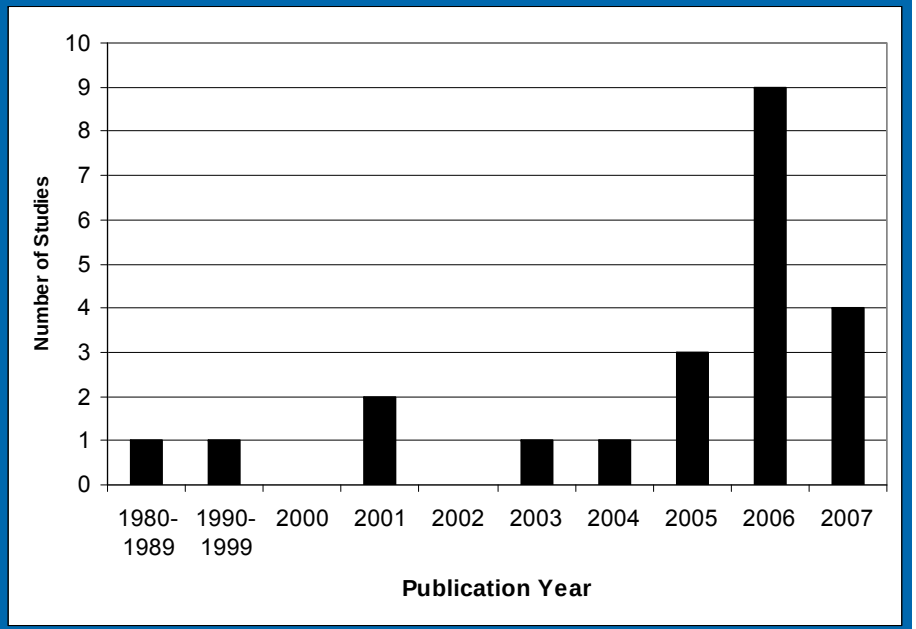
Evidence on Built Environment and Obesity in Children

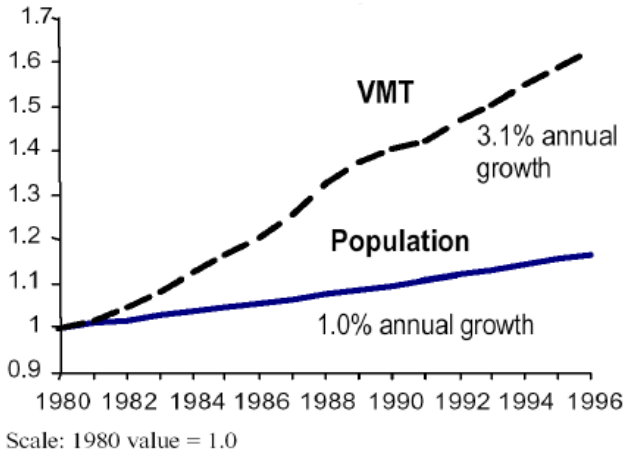
- BUT, evidence base is overwhelmingly cross-sectional (17 of 22: Dunton et al. in press)
- Possible "self-selection bias" – fit people chose to live in supportive neighborhoods



Need for Longitudinal and Traffic Studies

- No longitudinal studies on whether traffic affects development of obesity in children
- Overemphasis on urban form over function as traffic continues to increase quickly

FIGURE 2-3 GROWTH IN VEHICLE MILES TRAVELED & POPULATION (1980-1997)



Sources: U.S. Department of Transportation, Federal Highway Administration. Highway Statistics (Summary to 1995, and annual editions, 1996 and 1997), Washington, and Environmental Protection Agency, *Our Built and Natural Environment.*

Frumkin et al. (2004)

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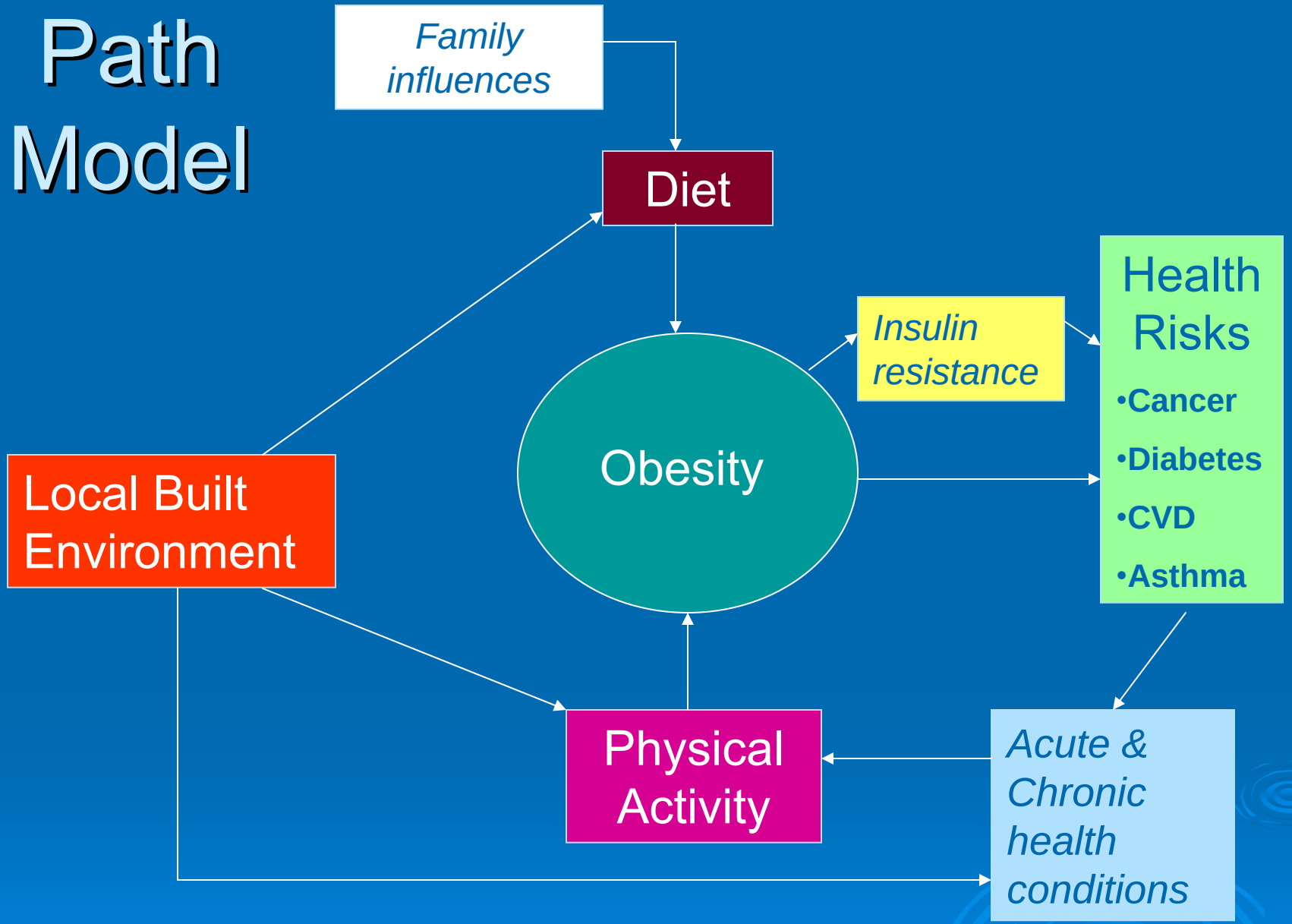
Path Model



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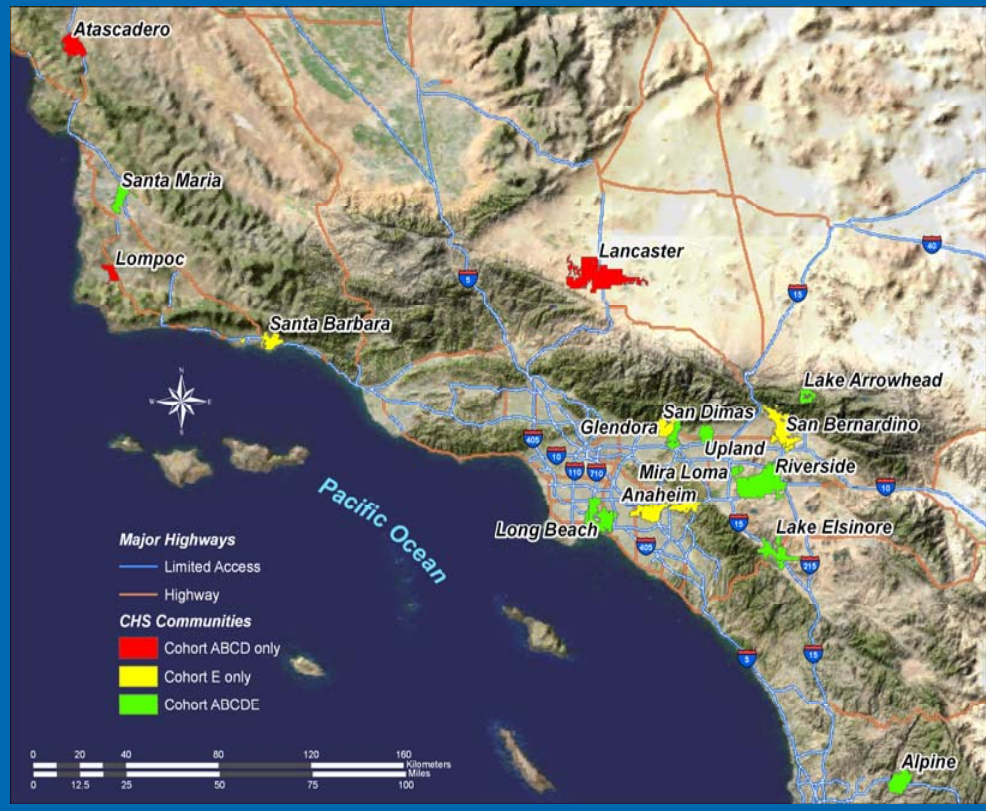
Data and Methods

- Childrens Health Study (N = 11,797)
  - Building on $50+ million prior investment
  - 16 Southern California communities
  - Up to 8 years of follow up
  - BMI (weight and height) measured yearly by trained staff



Geospatial Data

Land use, Transportation, Business locations

Public recreation facilities/programs, Green cover,

Air pollution

Characteristics of Analytic Cohort Age 10-18 in 12 Communities

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

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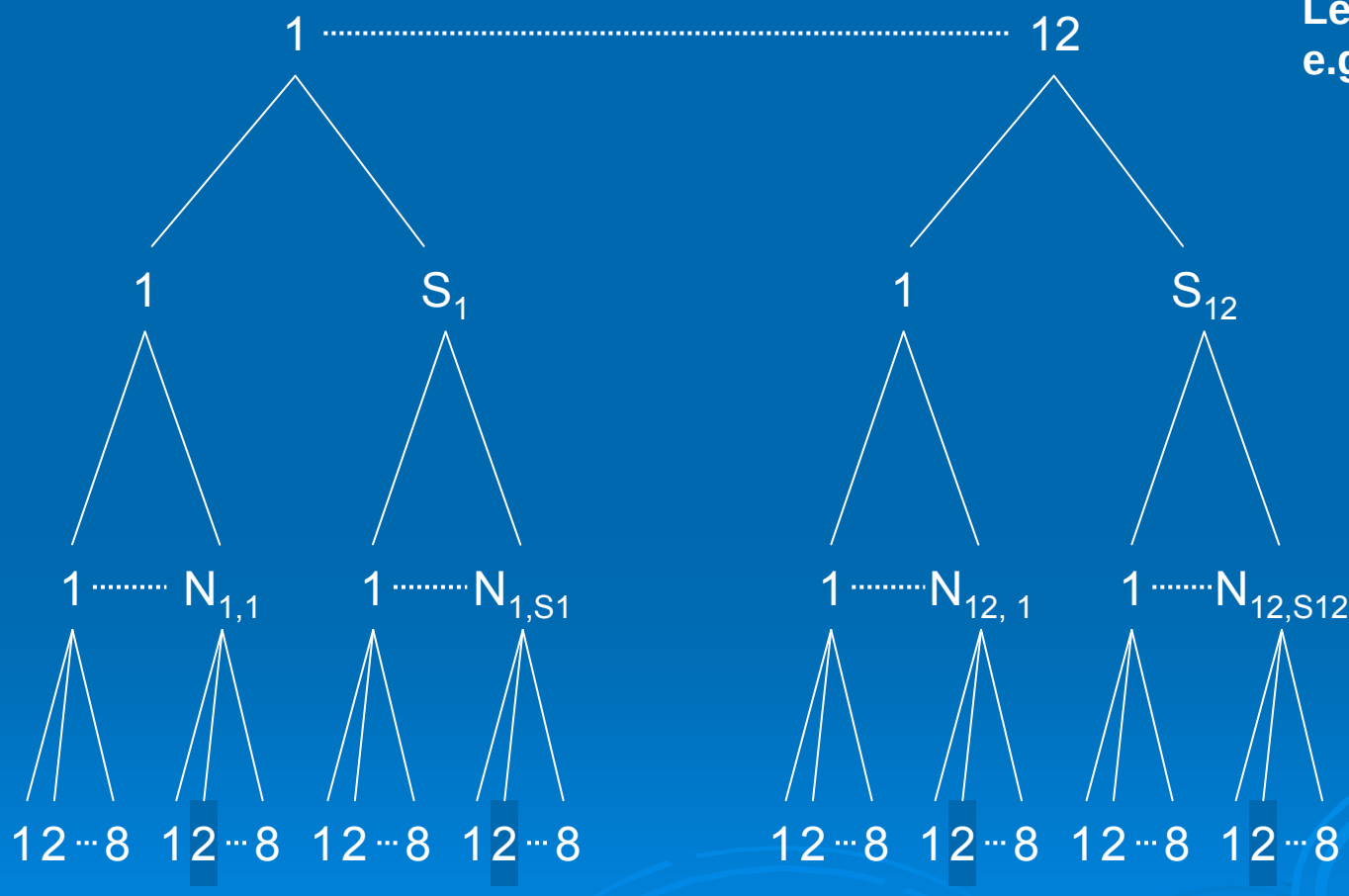
Multiple Levels of Built Environment Influences on Obesity



Level 4: Communities
e.g. Sprawl

Level 3: Schools
e.g., Food Access

Level 2: Individuals
e.g. Connectivity

Level 1: Time
e.g. Asthma, Smoking

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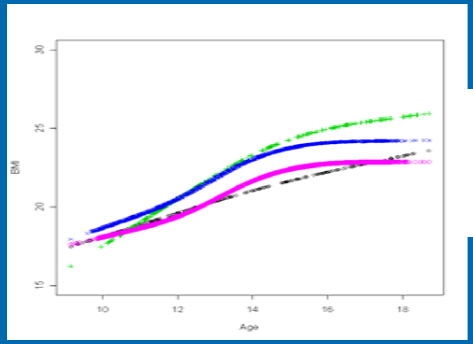
Modeling Approach for BMI Growth Curves

Y=BMI (kg/m^2), t=age, Z=built env., X=regional env.

1: $g[E(Y_{cij})] = a_{ci} + b_{ci}t_{cij}/8 + \delta f(t_{cij})$

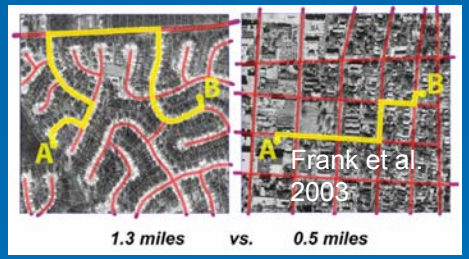
- b_{ci} = 8-yr BMI growth



Asian
Black
Hispanic
White

2: $b_{ci} = b_c + \beta_1(Z_{ci} - Z_c) + e_{ci}$

- β_1 : within-community BE effect



Frank et al. 2003

3: $b_c = \lambda + \beta_2 X_c + e_c$

- β_2 : between-community pollution effect, urban sprawl, crime

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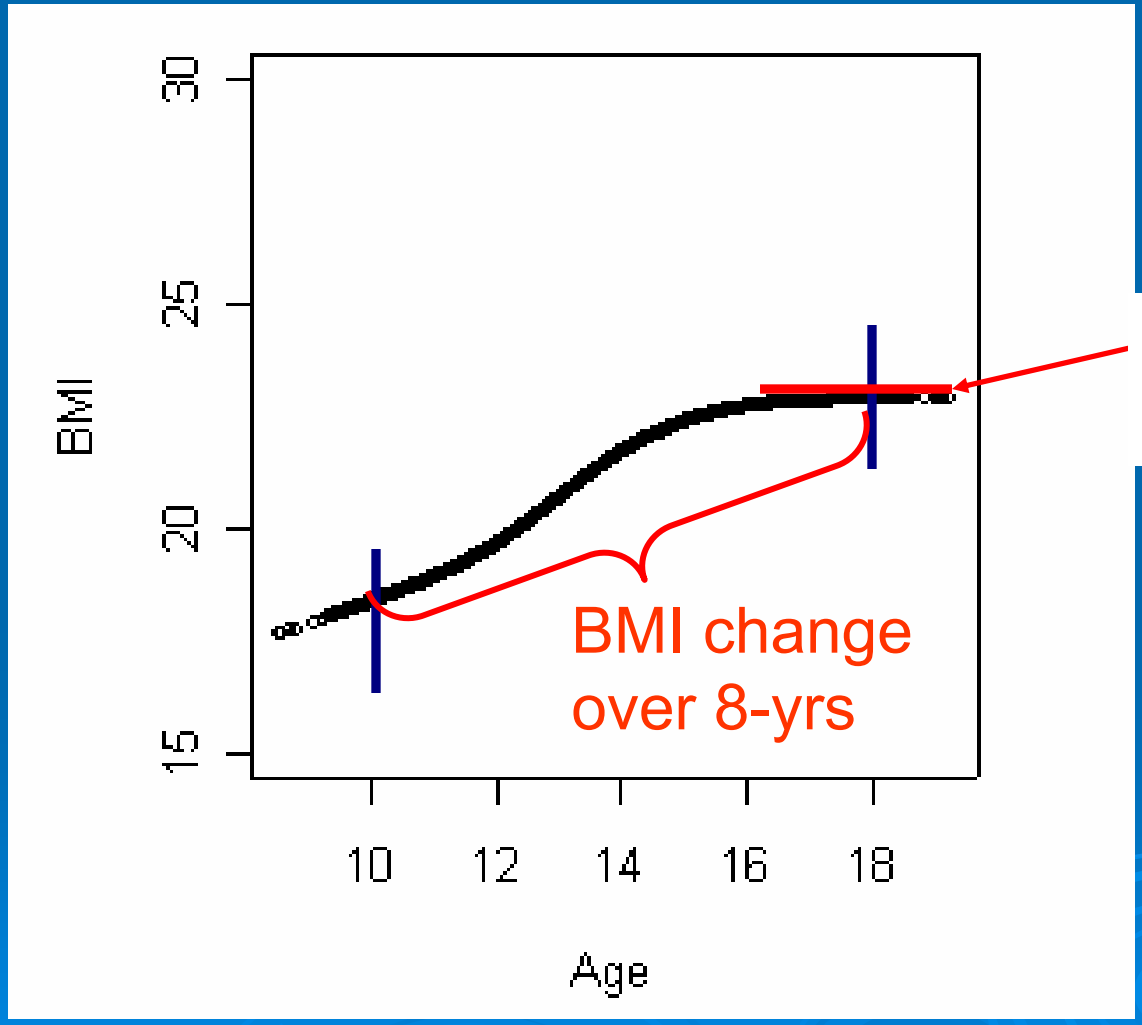
Models Focus on *Attained BMI at Age 18*



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Overweight Children Lead to Overweight Adults

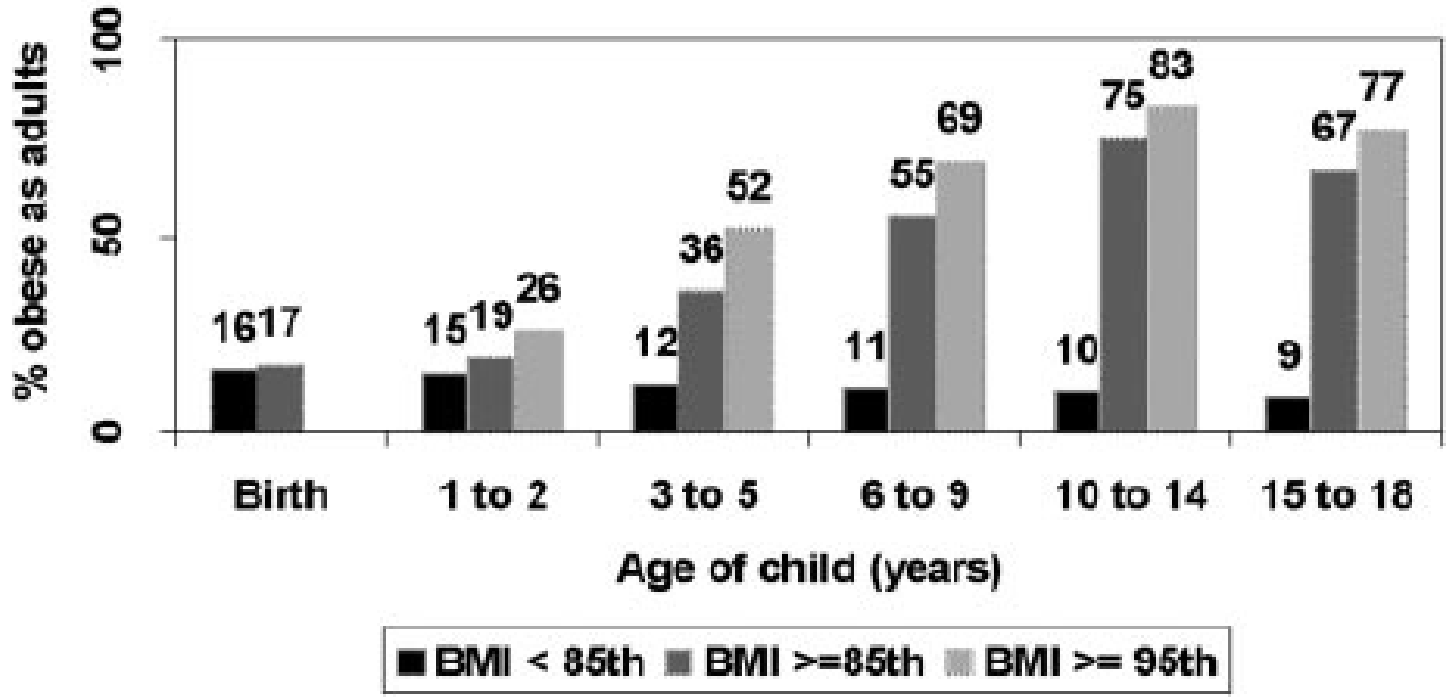
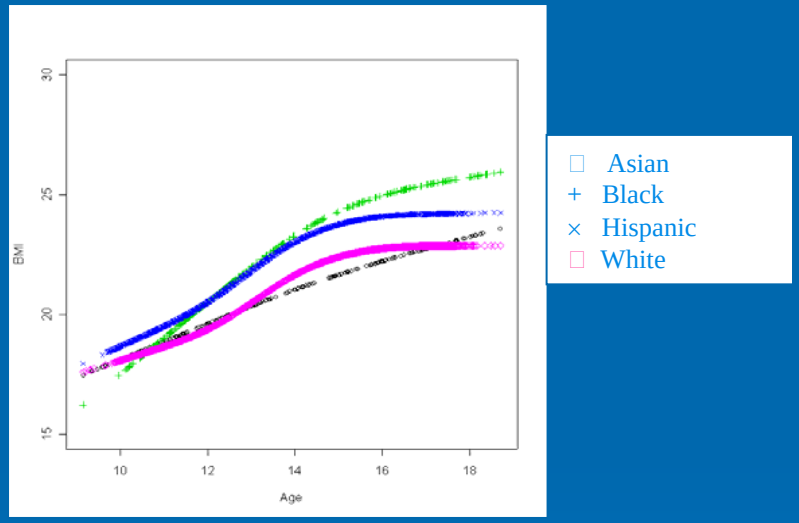


Figure 7: Tracking BMI-for-age from birth to 18 years with percentage of overweight children who are obese at age 25. Reprinted with permission from Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med.* 1997;337:869–73.

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

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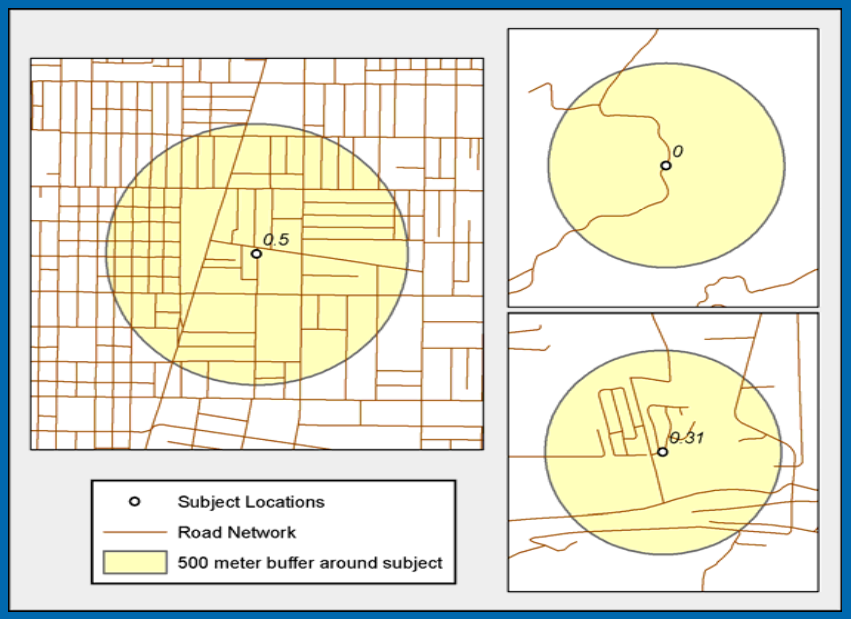
Level 2: Between subjects/within community



Allows for:

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

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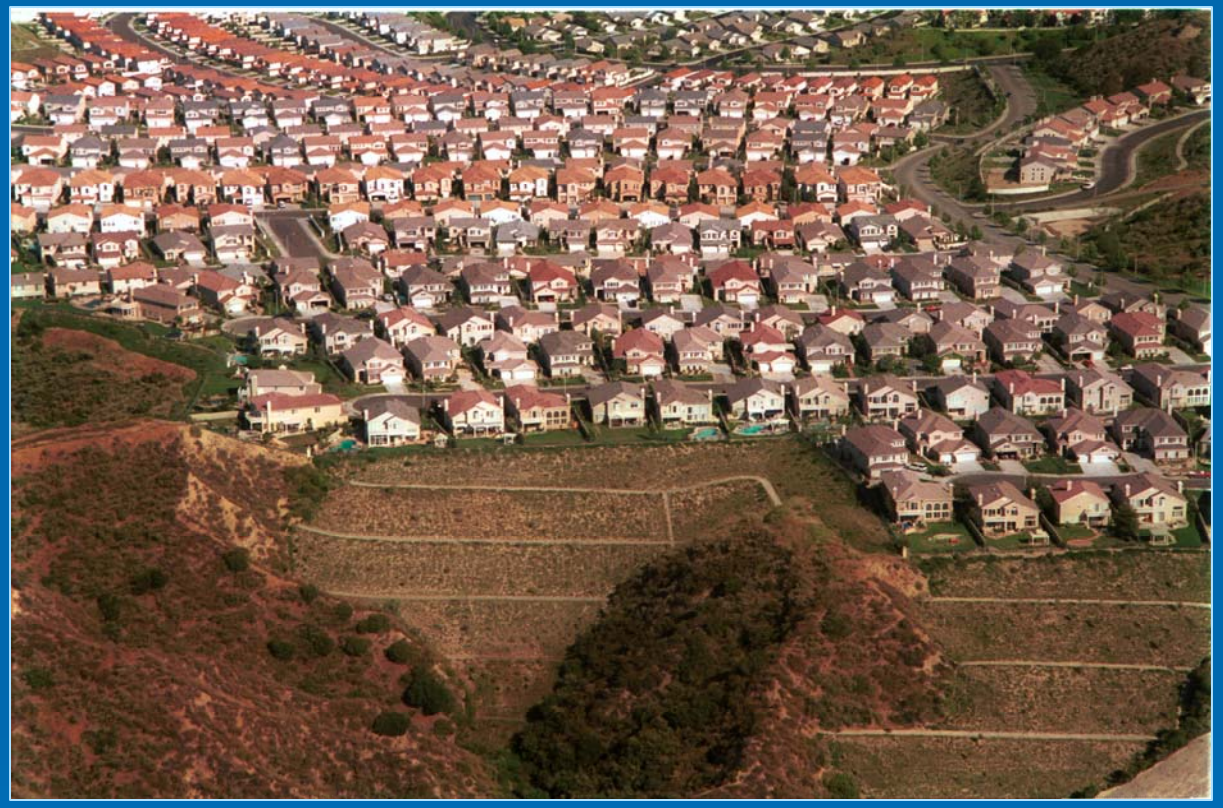
Level 3: Between communities



Allows for:

- Between-community pollution effect, urban sprawl, crime, social conditions

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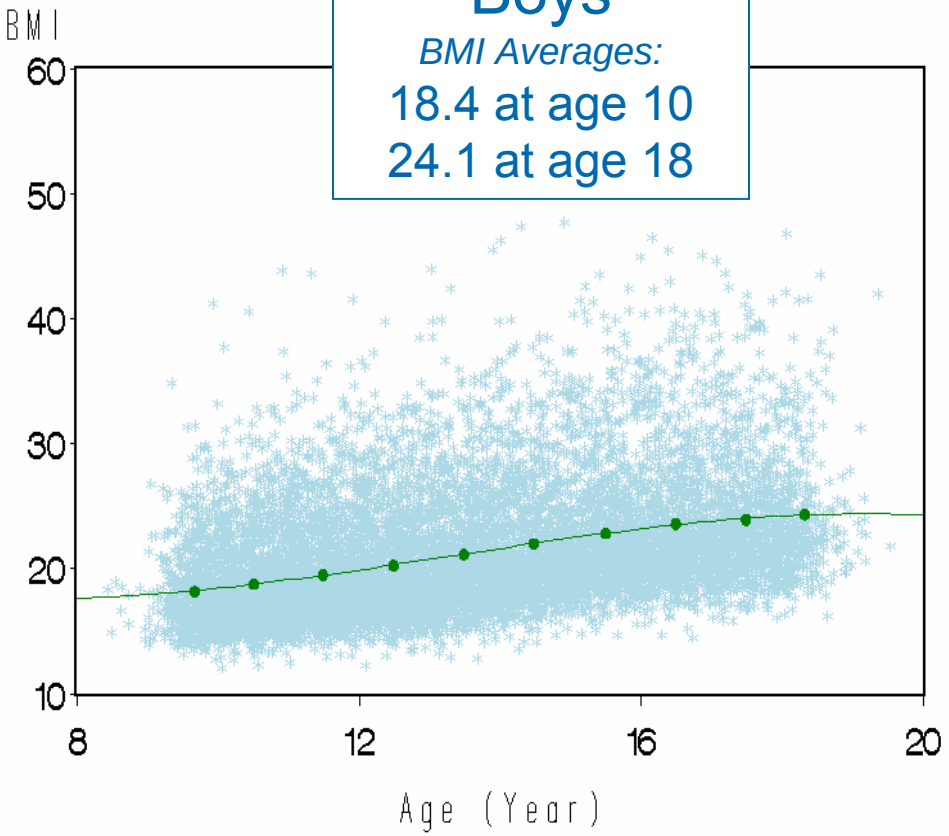
BMI Growth Over 8 Years

Boys

BMI Averages:

18.4 at age 10

24.1 at age 18

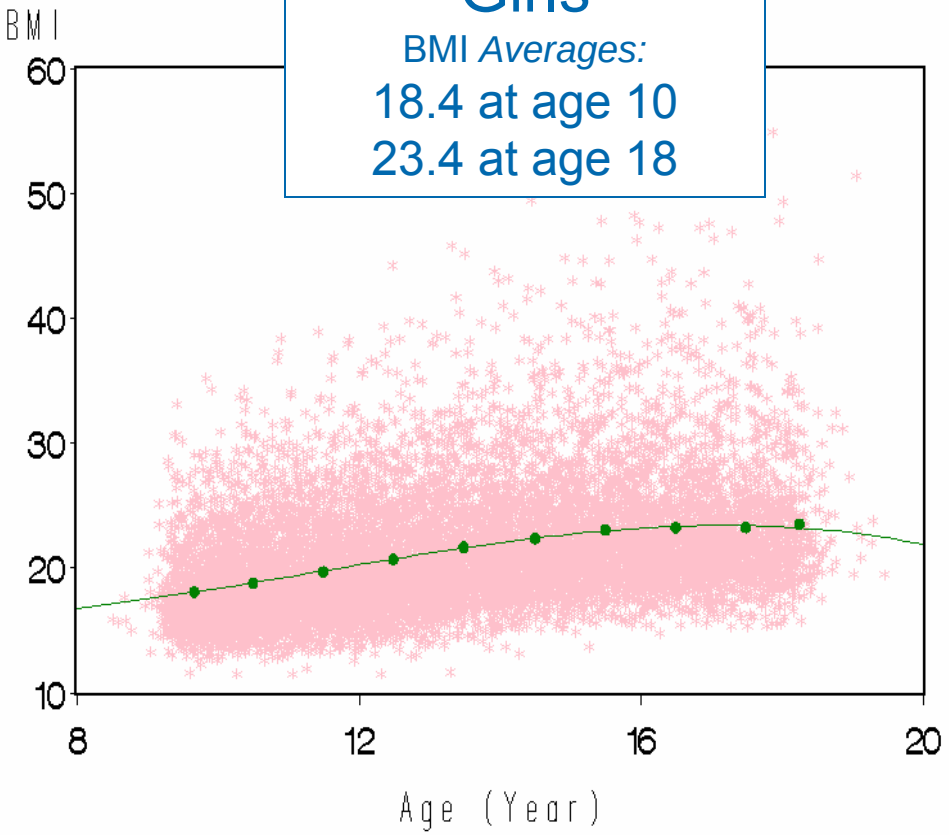


Girls

BMI *Averages:*

18.4 at age 10

23.4 at age 18



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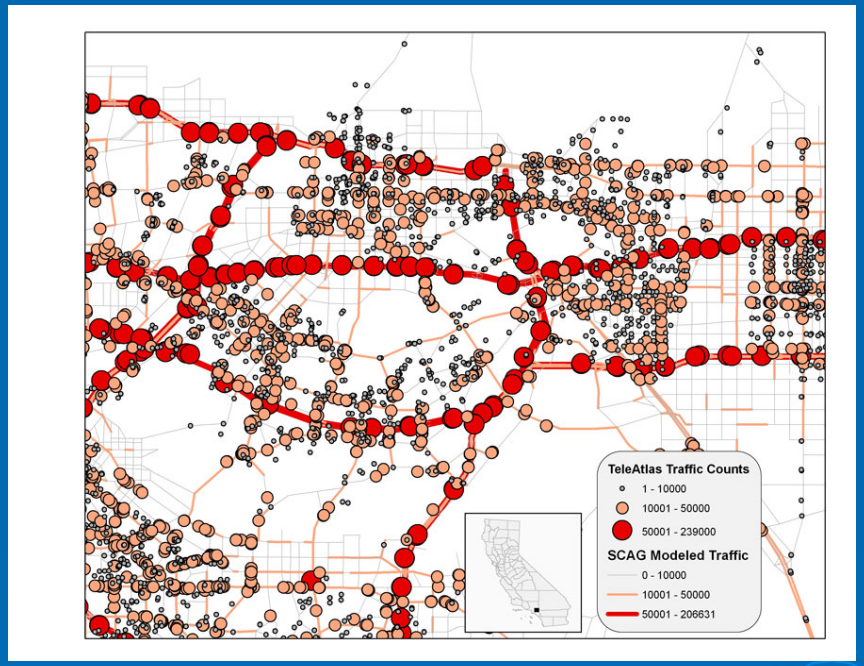
Traffic Exposure Variable

- California Dept of Transportation High Performance Monitoring System Data
- Conflated to TeleAtlas Road Network
- Estimated based on link data
- Kernel estimate with distance decay set to 90% for 150 m, 300 m, and 500 m buffers



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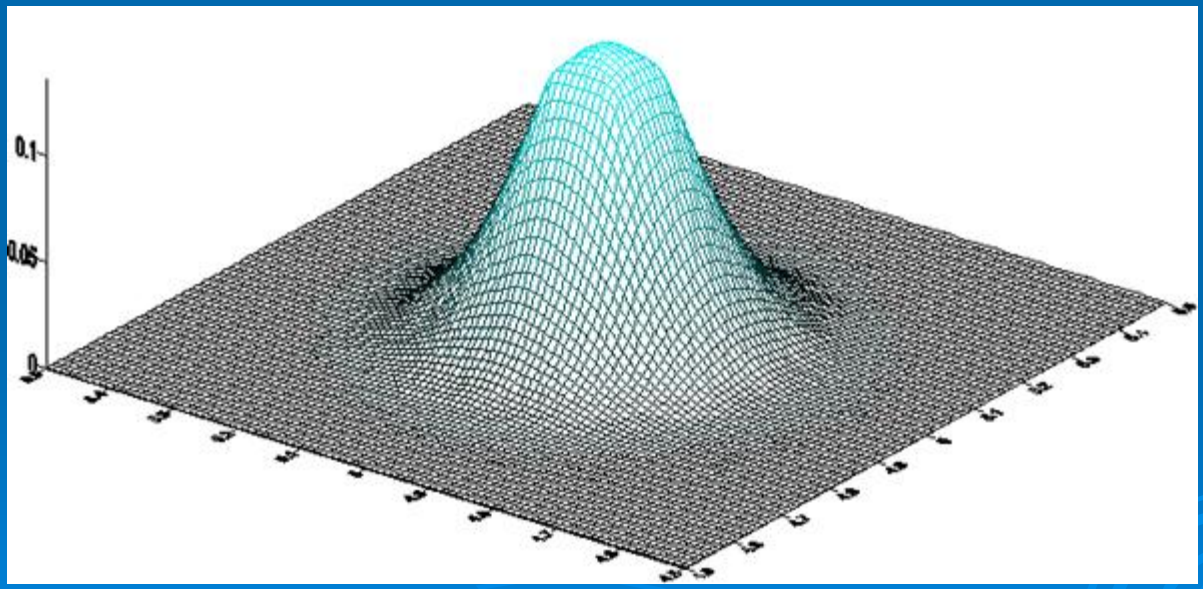
Kernel Estimate

- Continuous density surface that down-weights traffic as a function of increasing distance from the child's home



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Summary of Variables Tested as Possible Confounders

	Measurement Scale							
Variable Type	Individual Attributes	Household	Residence Euclidean Buffer	Residence Network Buffer	School Location	School Euclidean Buffer	Census Tract	Town Level
SES		9			18		5	5
Health	18							
Smoking	5	6						
Sports	4							
Recreation Access			6					
Land Use			51					
Traffic			16					
Air Pollution		6			6			8
Elevation		1	5					
Food			7	7		14		
Road Connectivity			10					
Green Cover		1	1					
Sprawl								23

Model Selection

- Confounders tested and included if:

a. They have association with BMI growth
b. They change the traffic exposure effect by 10% or more

- All models control for age, race, cohort, and town of residence

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Confounders of Traffic Around the Home

Design Variables

- Gender
- Ethnicity/Race
- Cohort of enrollment
- Town indicator (fixed or random effect)

Individual and Household Level

- Parental education
- Personal smoking
- Second hand smoke
- Asthma status
- Foreign born status

Neighborhood and Community Level

- Population density
- Street connectivity (Gamma Index)
- Neighborhood poverty
- NDVI remote sensing greenness measure
- Lack of food access
- Violent crime in community

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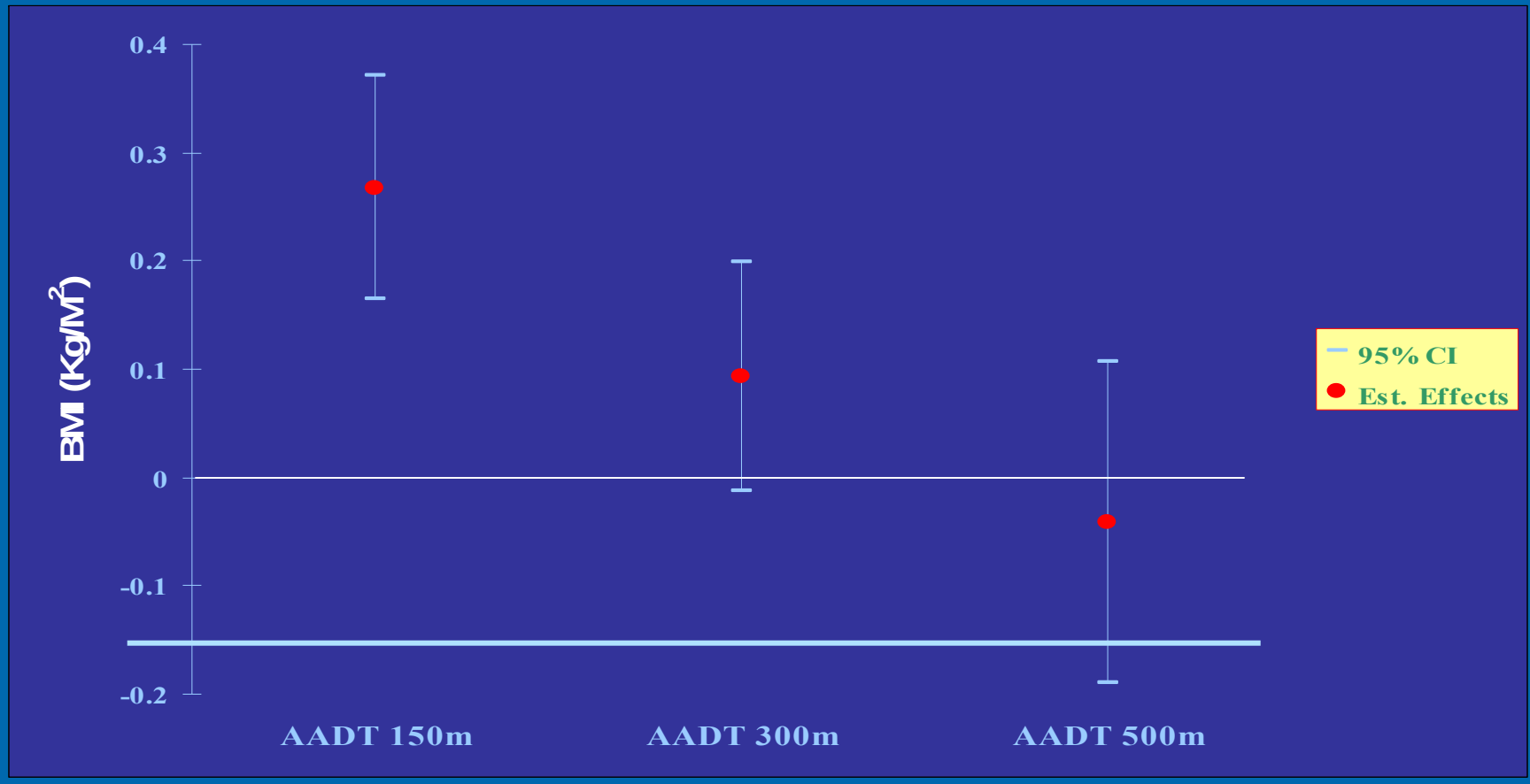
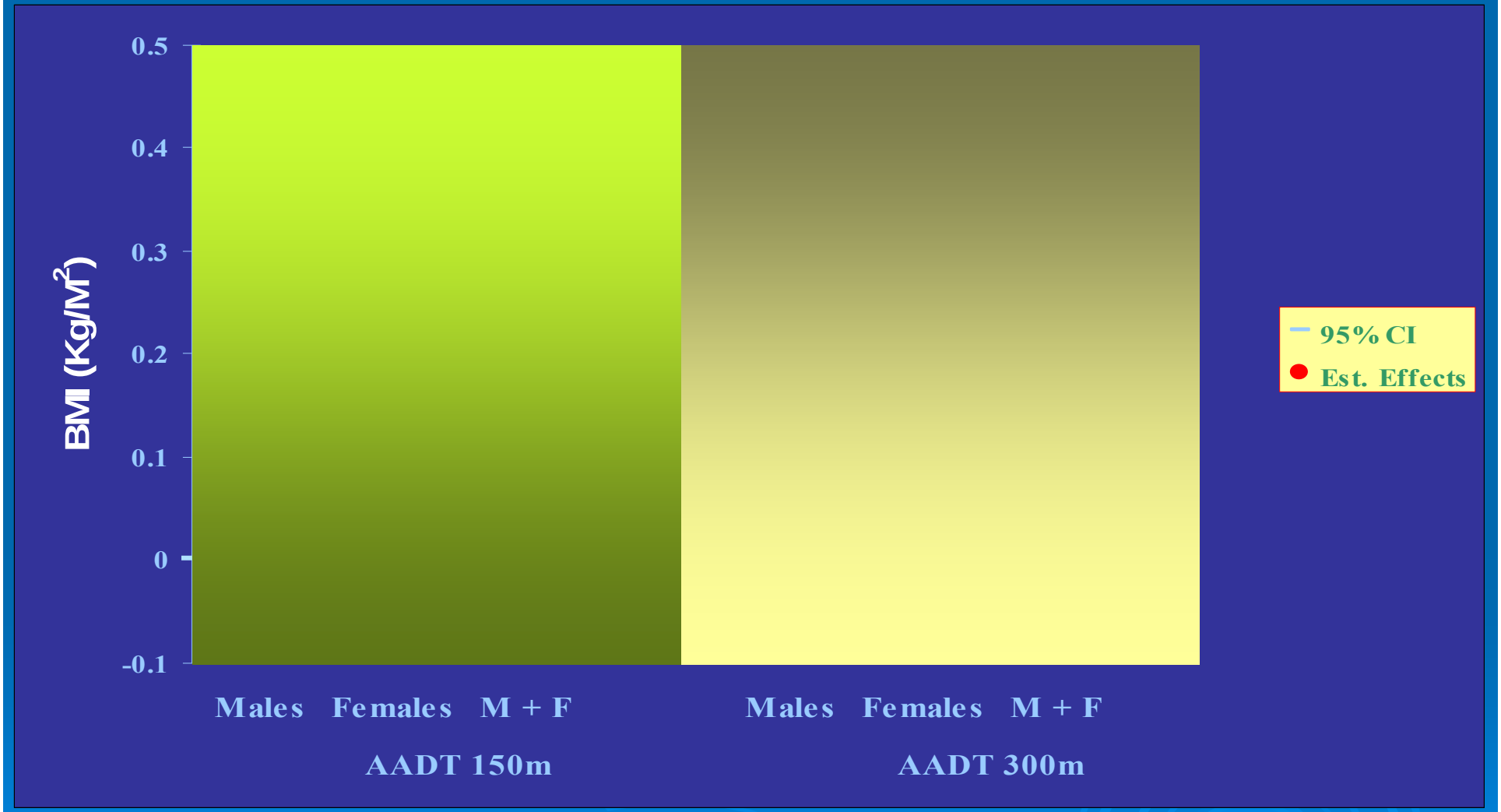
Results: Effects of Traffic at 150 m, 300 m, and 500 m on Attained BMI



Confounders: Ethnicity, Gender, Cohorts variables, in addition, adjusted for **Parental Education, Personal Weekly Smoking, Second Hand Smoke (Current + Past), Ever Asthma, Buffer Population, Gamma Index, Proportion of Below Poverty People within Census Block, NDVI, Foreign Born, Town Level Violent Crime Rate, and Having No Food Stores within 500m Road Network Buffer** with Random Town Effects

Comparison of 150 m and 300m Traffic



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Summary of Results

- 150 m traffic exposure is a highly significant predictor of BMI growth for boys and girls
- 300 m traffic exposure weaker effect and larger in girls
- 500 m effect confounded by other variables such as density and street connectivity

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Effect Size Interpretation

- Evaluated against the average 8-year growth, 10-90%ile contrast in 150 m traffic increases BMI by about 5%

- Although effects appear moderate, they potentially affect large populations; therefore public health impact may be substantial

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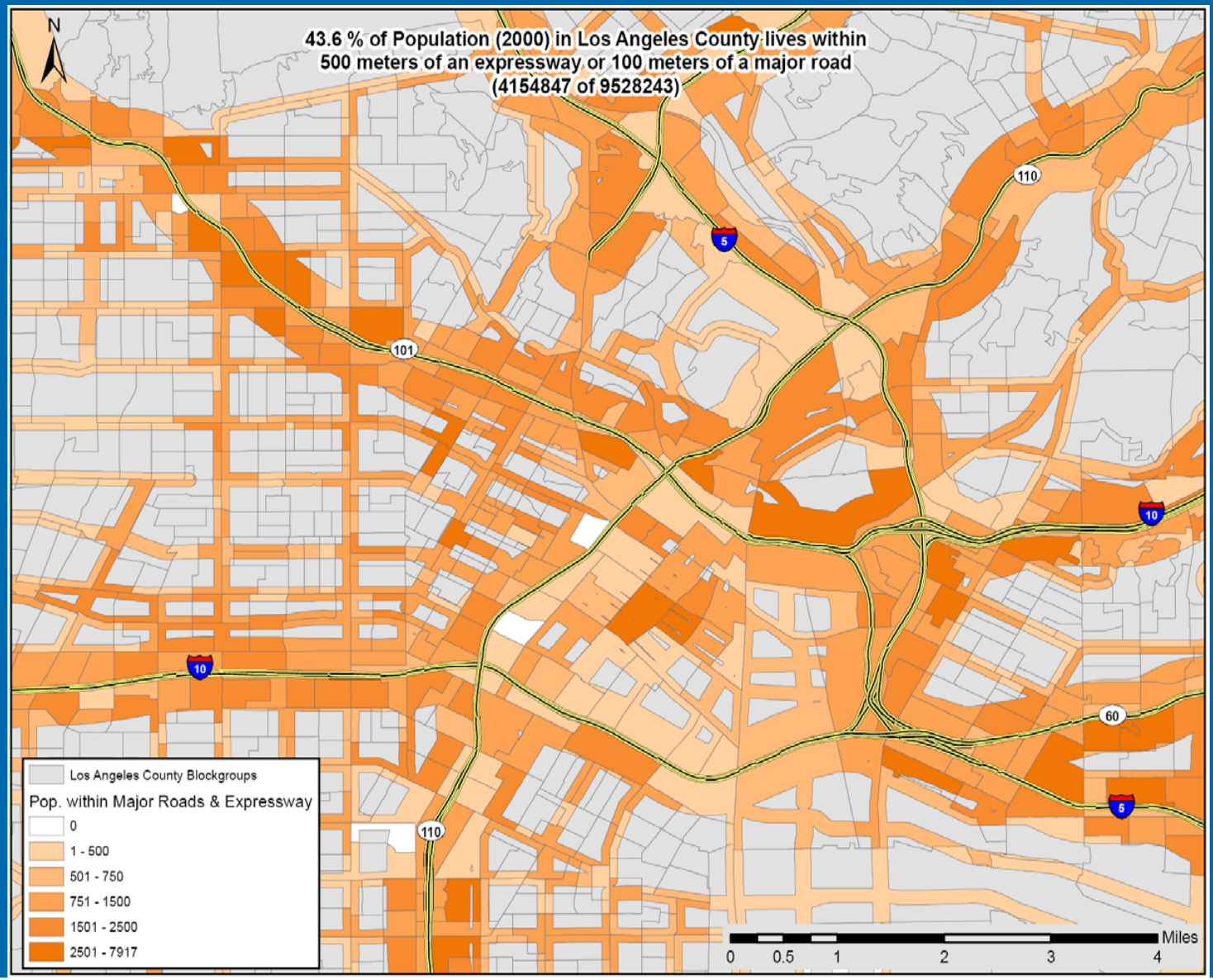
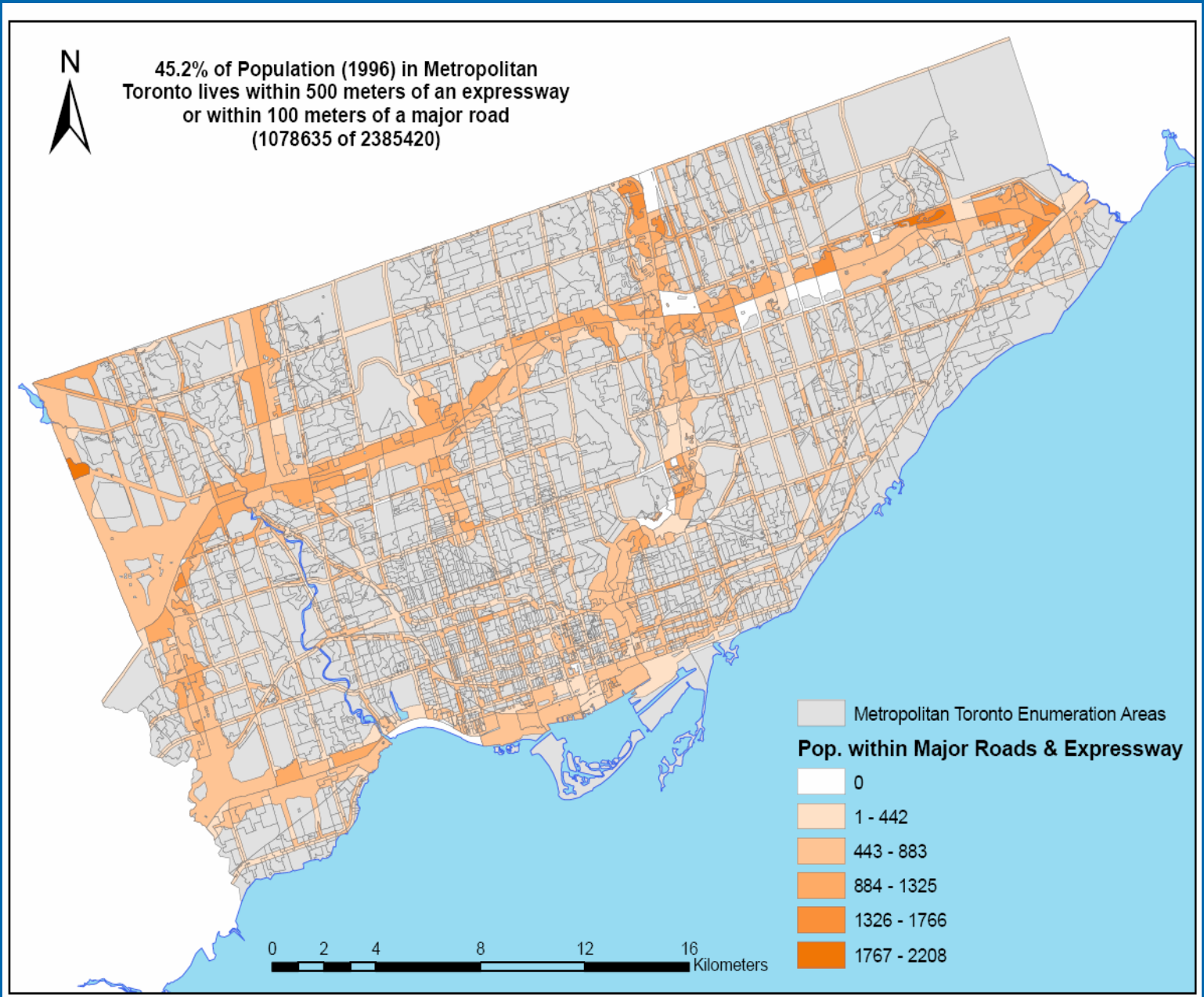
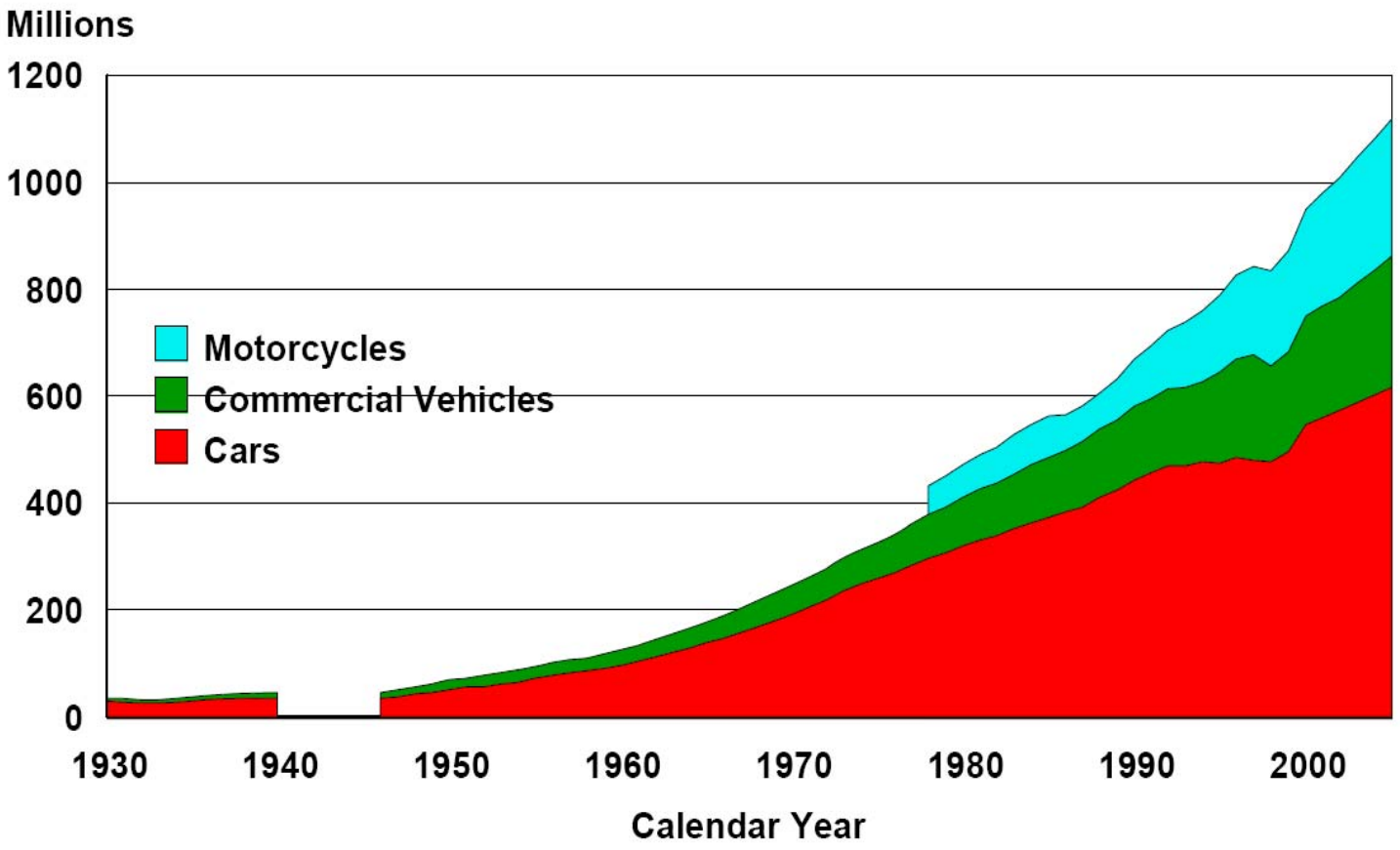
Los Angeles Example: ~44% of Population Exposed



Toronto Example:
~45% Population Exposed



World Population of Vehicles: 1 Billion+



Walsh (2007) *In preparation*

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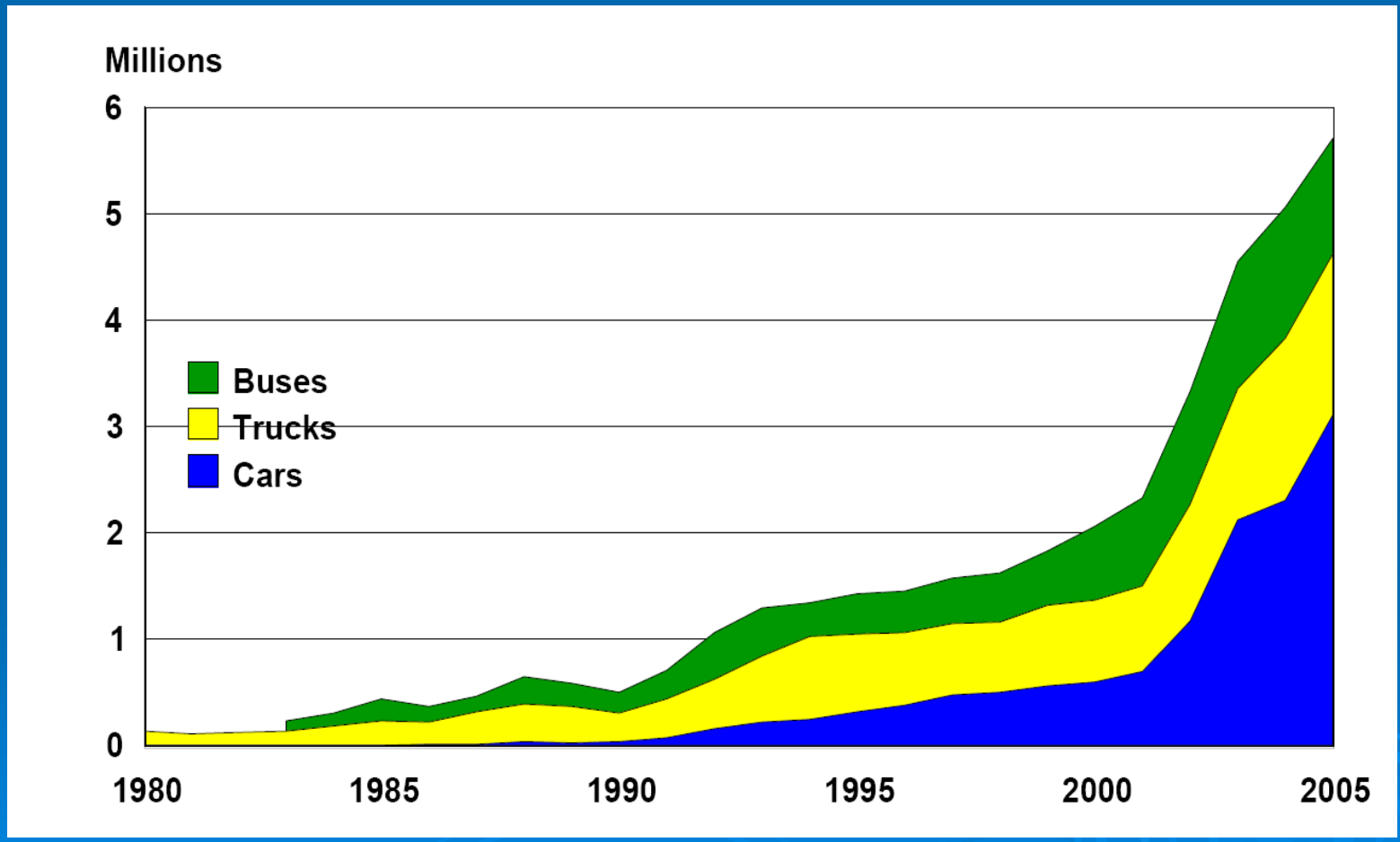
Production of Vehicles in China



Walsh (2007) *In preparation*

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Explanations of Traffic Effect: 1. Safety and Physical Activity

- Traffic creates sense of danger and inhibits mobility by foot and bike – leads to lower physical activity and positive energy balance

- Supported by some studies suggesting perceived traffic danger lowers physical activity in children and youth

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2. Traffic Contributes to Chronic Disease

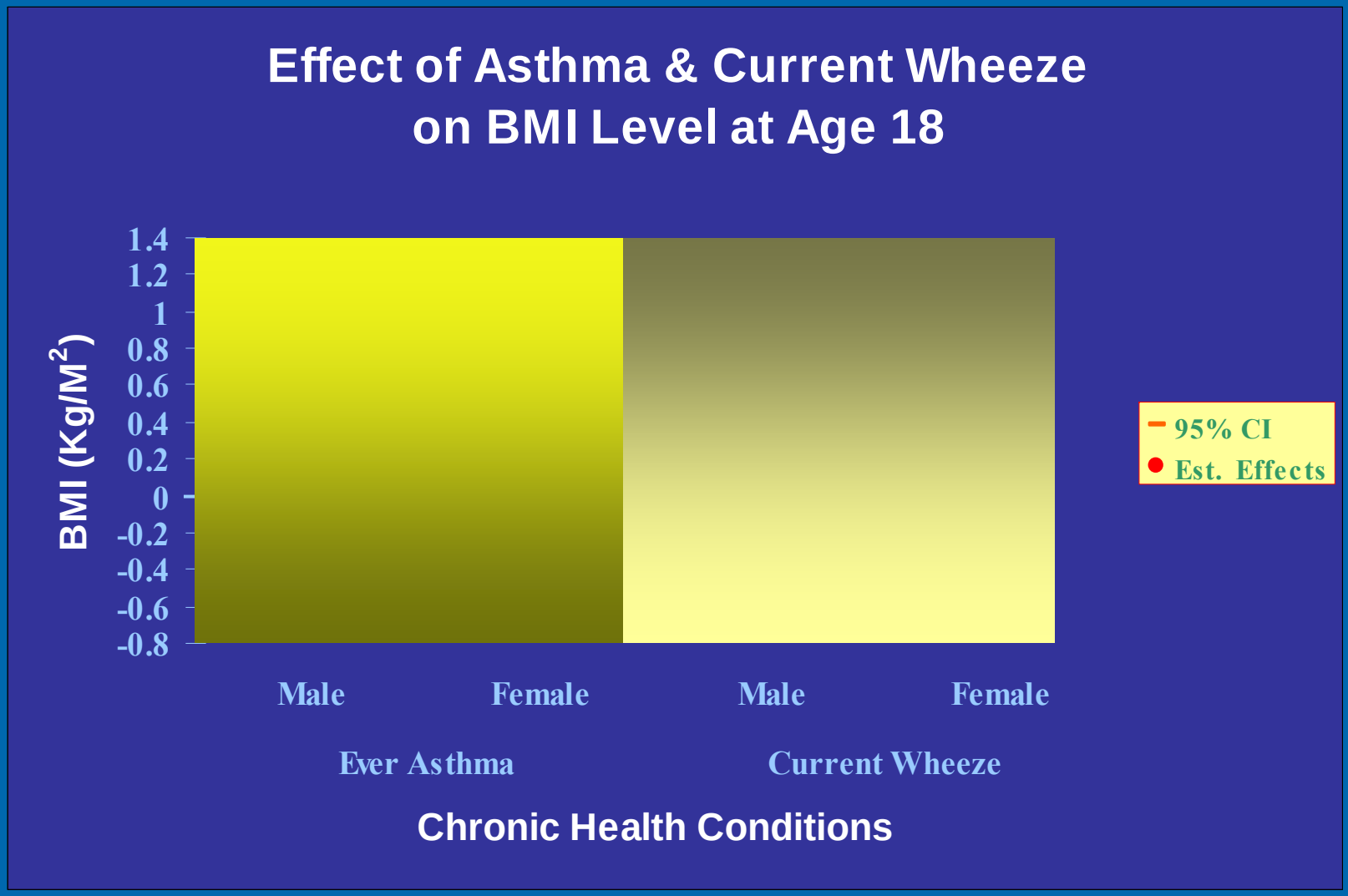
- Air pollution associated with decrements of lung function growth and prevalent/incident asthma in this cohort

Traffic-Related Air Pollution and Asthma Onset in Children: A Prospective Cohort Study with Individual Exposure Measurement

Michael Jerrett,[1] Ketan Shankardass,[2] Kiros Berhane,[2] W. James Gauderman,[2] Nino Künzli,[3] Edward Avol,[2] Frank Gilliland,[2] Fred Lurmann,[4] Jassy N. Molitor,[5] John T. Molitor,[5] Duncan C. Thomas,[2] John Peters,[2] and Rob McConnell[2]

- Asthma and other respiratory conditions associated with increases in 8-year BMI growth
- Effects of traffic really represent undiagnosed chronic respiratory disease

Chronic Disease and BMI Growth



3. Air Pollution Contributes to Metabolic Disorders

- Recent evidence suggests environmental air pollution may cause metabolic disorders including pro-obesity conditions at cellular level

Ambient Air Pollution Exaggerates Adipose Inflammation and Insulin Resistance in a Mouse Model of Diet-Induced Obesity

Qinghua Sun, Peibin Yue, Jeffrey A. Deiuliis, Carey N. Lumeng, Thomas Kampfrath, Michael B. Mikolaj, Ying Cai, Michael C. Ostrowski, Bo Lu, Sampath Parthasarathy, Robert D. Brook, Susan D. Moffatt-Bruce, Lung Chi Chen and Sanjay Rajagopalan

- Physiopathology of air pollution from traffic may include metabolic effects

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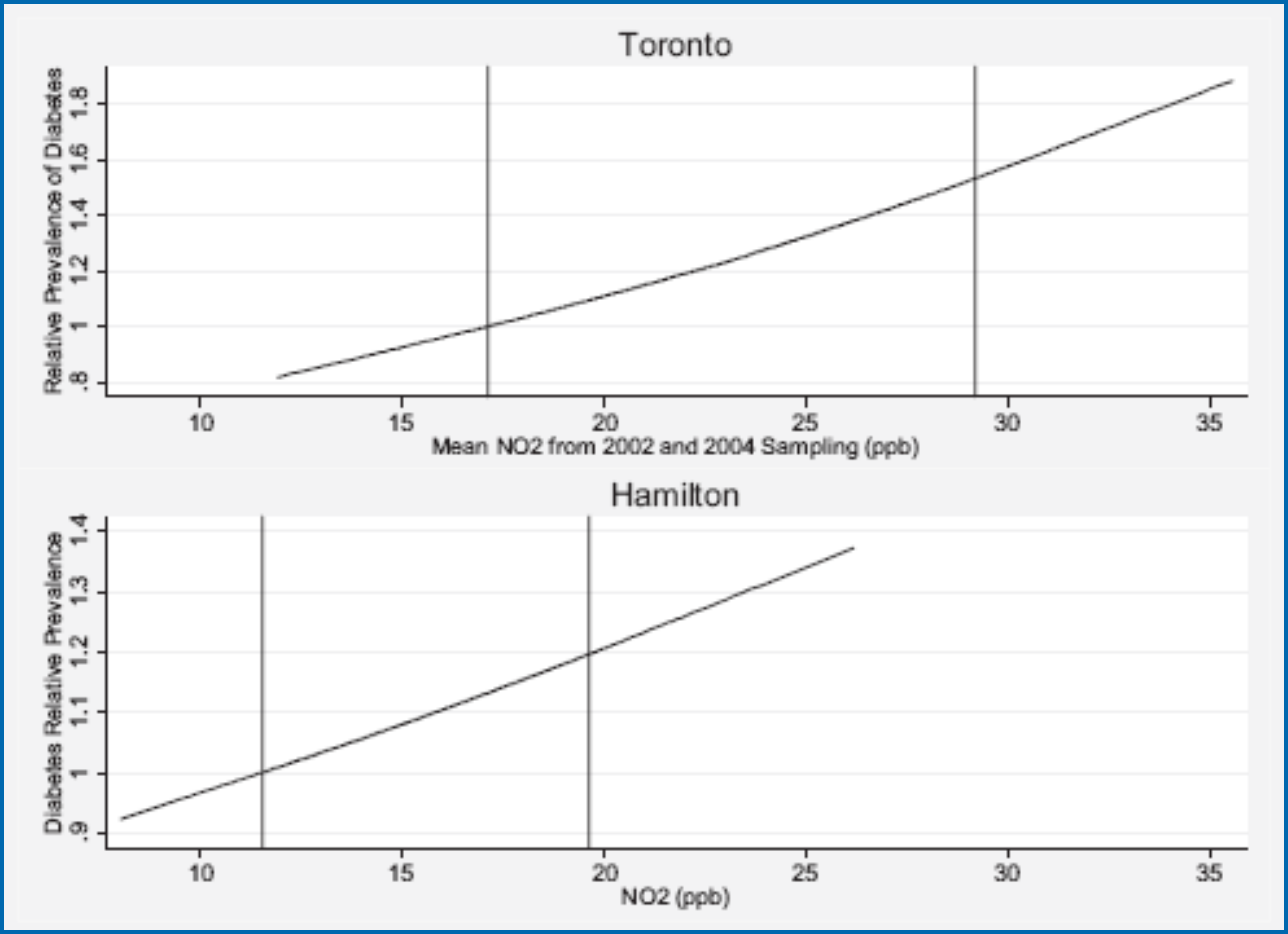
Diabetes and Air Pollution

- Other evidence links air pollution to diabetes in women



Robert D. Brook, MD
Michael Jerrett, PhD
Jeffrey R. Brook, PhD
Robert L. Bard, MA
Murray M. Finkelstein, MD, PhD

The Relationship Between Diabetes Mellitus and Traffic-Related Air Pollution

Concluding Prevention Possibilities

- Implement traffic calming to improve safety in impacted neighborhoods

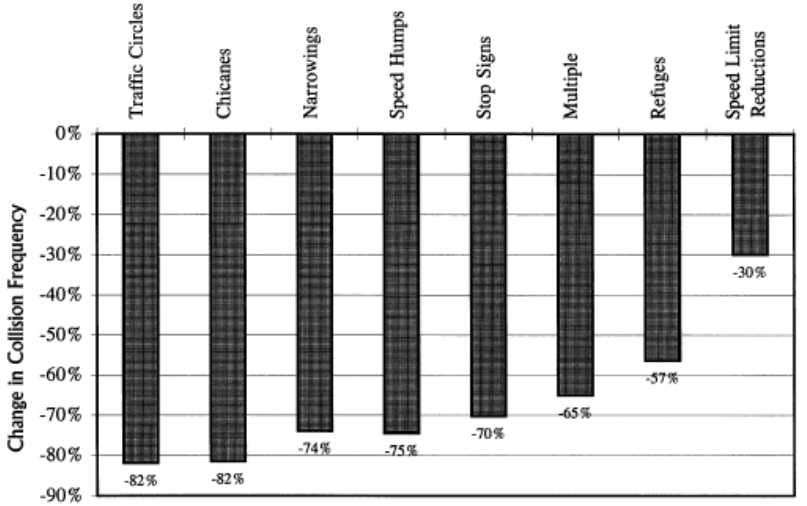
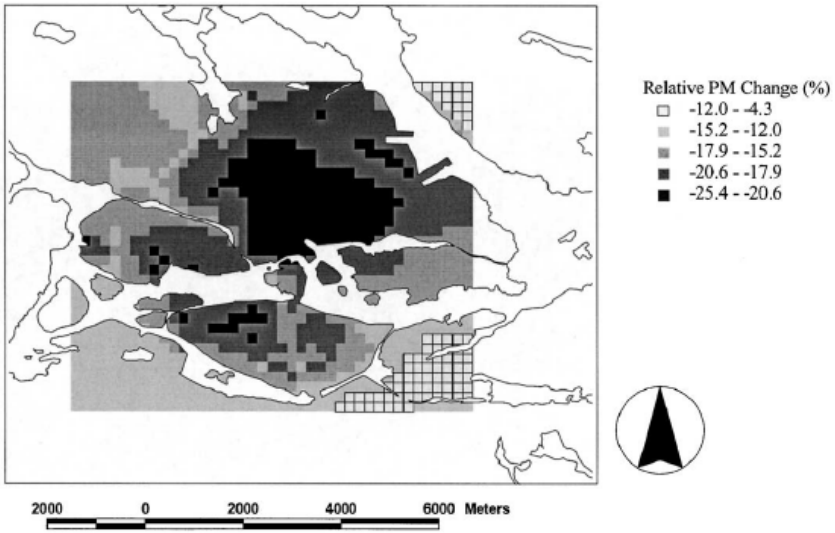


FIGURE 11 Average percent reduction in collisions per measure.

- Environmental Green Zones to prevent air pollution in sensitive areas



Future Directions

- Focus on younger children aged 5-10 – does traffic affect them in the same way?
- Examining effects of air pollution directly to test alternative hypotheses
- Focusing on school environments – separate traffic effects from home?

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