The Integration of Urban Form and Public Health

Developing and translating metrics into policy
### Brief Chronology

#### AJPH June 2000, Vol. 90, No. 6
- Featuring Urban Health
- N. Freudenberg Editorial
  - Time for a National Agenda to Improve the Health of Urban Populations

#### Research Agendas
- NIEHS (2002)
  - Final Report: Built Environment – Healthy Communities, Healthy Homes, Healthy People
- CDC (2002)
  - The Impact of Community Design and Land-Use Choices on Public Health: A Scientific Research Agenda

#### AJPH September 2003, Vol. 93, No 9
- Featuring Built Environment and Health Impact

#### AJHP September 2003 Vol. 19, No. 1
- Featuring Built Environment and Health Impact

#### Academic Papers & Reports
Explaining Exposure and Health Outcomes...

...is a Complex Mix

- Genetic
- Medical Care
- Behavioral Choices
- Environmental Conditions
- Social Circumstances
Good at surveillance. Bad on remediation

- It is important to recognize that assessment is part, but not all of the story

“You guys are great at finding the problem, but I can’t go tell the mayor and alarm whole communities when I don’t have the means to pay for a solution”

– Comment from a District Level Health Director
Moving from Mitigation to Primary Prevention

The need for innovative methods and tools

- Children’s environmental health programs remain mitigative instead of preventive and require a body count to precipitate action – the *Canary in the Mine* approach!

- Developing innovative methods to identify currently vulnerable populations and improve their condition prior to exposure is a vital step toward making the U.S. Healthy People 2010 goal – “healthy people in healthy communities” – a reality rather than a slogan.

- Using GIS and prediction modeling, for example, is helping us to develop scientifically sound primary prevention strategies as a basis for policy development.
A Brief Summary
of What We Know

**Translating Metrics:**

- Environmental Outputs
  - Dose-Response
- Overweight/Obesity
  - Modifiable features
- Healthcare Costs
  - Health favorability
- Economic Impact of Lead Exposure
  - Cost v. Benefit
Environmental Outputs

_Dose - Response_
The Detrimental Impacts of Land Use and Transportation

- ↑ air pollution
- ↑ heat island effect
- ↑ car crashes
- ↑ pedestrian injuries
- ↓ water quality
- ↓ mental health
- ↓ social capital
- ↓ PHYSICAL ACTIVITY
  - Sprawl

# Air Quality Thresholds

<table>
<thead>
<tr>
<th>Urban Planning Component/Effector</th>
<th>Pollutant</th>
<th>Source(s)</th>
<th>Standard</th>
<th>Exposure Pathway</th>
<th>Potential Mitigant</th>
<th>Human Health Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Design; Transportation; Land-Use; Housing</td>
<td>Criteria Pollutants – O₃, PM 10 – 2.5, CO, Sox, NOₓ, Pb</td>
<td>Motor vehicle exhaust; Industrial discharge; Impervious surfaces; Construction.</td>
<td>See O₃ example below</td>
<td>Inhalation and ingestion as a result of atmospheric dispersion and subsequent contamination of soil, water, and vegetation through precipitation</td>
<td>Human-focused urban design and land uses</td>
<td>Breathing difficulties; aggravate heart and lung disease, and result in premature death.</td>
</tr>
<tr>
<td>Urban Design; Transportation; Land-Use; Housing</td>
<td>Ozone (O₃)</td>
<td>Motor vehicle exhaust; fossil fuel combustion from power plants; impervious surfaces. Principal component of urban smog.</td>
<td>1-hr average – 0.12 ppm; 8-hr average – 0.08 ppm (NAAQS)</td>
<td>Inhalation – primary route</td>
<td>Human-focused urban design and land uses emphasizing open space and a reduction in impervious surface coverage.</td>
<td>Breathing difficulties; reduced lung function, asthma, eye irritation, nasal congestion, ↓ resistance to infection, damage to trees and crops.</td>
</tr>
</tbody>
</table>

National Ambient Air Quality Standards – [http://www.epa.gov/air/criteria.html](http://www.epa.gov/air/criteria.html). **Primary standards** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. **Secondary standards** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.
## Water Quality Thresholds

<table>
<thead>
<tr>
<th>Urban Planning Component/Effector</th>
<th>Pollutant(s)</th>
<th>Source(s)</th>
<th>Standard</th>
<th>Exposure Pathway</th>
<th>Potential Mitigant</th>
<th>Human Health Effect</th>
</tr>
</thead>
</table>
| Urban Design; Transportation; Land-Use; Housing | Stormwater runoff and related non-point source pollutants – arsenic, nitrates, copper, nickel, zinc, hexavalent chromium, cadmium, lead, mercury, ammonia, phosphorus and nitrogen, pH, dissolved oxygen, siltaton, bacteria, oil, cyanide, herbicides and pesticides, and other heavy metals | Non-point sources primarily from urban – impervious surfaces – and rural – agricultural lands – runoff | Not currently known            | Runoff occurs when water runs over land or through the ground, picks up pollutants and deposits them in surface water or introduces them to groundwater. These pollutants have harmful effects on drinking water supplies, soil continuity, recreation, fisheries, and wildlife. | More efficient use of Transportation planning and attention to human-focuses land uses and urban design emphasis on open space and sustainable development.  
Pervious surface replacement.  
Urban forestry solutions.  
Green roofs. | Headache, dizziness, weakness, feelings of anxiety, blurred vision, nausea, vomiting, abdominal cramps, slow pulse, diarrhea, damage to the pancreas, enlargement of the thyroid, loss of muscle coordination, skin allergies, physical and mental growth impairment in children, liver cancer, anemia, and leukemia, affects to fetal development... |
Overweight/Obesity
Modifiable Features in the Built Environment

The Specter of Sprawl
Suburbia USA: Fat of the Land?

Report Links Sprawl, Weight Gain

Suburban sprawl appears to be contributing to the nation's obesity epidemic, making people less likely to walk and more likely to be overweight, researchers reported yesterday.

In the first comprehensive examination of whether suburbs spreading across the U.S. landscape are affecting Americans' health, the researchers studied more than 200,000 people in 448 counties, producing the first concrete evidence supporting suspicions that sprawl is aggravating the nation's growing weight crisis.

People who live in the most spread-out areas spend fewer minutes each month walking and weigh about six pounds more on average than those who live in the most densely populated places. Probably as a result, they are almost as prone to high blood pressure as cigarette smokers, the researchers found.

"There are a lot of other reasons why we should work to contain sprawl," said Reed Ewing of the University of Maryland's National Center for Smart Growth, who led the research team. "But if you are on the road a lot, you're going to be sedentary, you're going to be eating more, and you're going to be overweight."

People who live in the most spread-out areas were found to weigh about six pounds more on average than those in the most densely populated places. It's a matter of "exposure and opportunity," Ewing said. "It's a very personal question, and it's also a very personal responsibility."

20 densest counties

People in more spreading counties are also likely to have a higher body mass index (BMI), a standard measure of weight. A 30-point increase in the degree of sprawl was associated with an average weight gain of a little more than one pound per person, researchers found.

While researchers found no association between sprawl and diabetes or heart disease, they did find that people who live in the least sprawling areas had a 20 percent lower risk of developing high blood pressure than those in the most sprawling states.

Sprawl and Obesity

New research links suburban sprawl to obesity. You are more likely to be overweight, live in an area with low population density and a more expansive street grid.
Difference between most and least sprawling counties?

6.4 pounds per person

Land Use Affects Our Level of Physical Activity

FACTS:

• Residents in highly walkable neighborhoods engage in about 70 more minutes per week of moderate and vigorous physical activity than residents in low-walkable neighborhoods.

• Forty-three percent of people with safe places to walk within ten minutes of home met recommended activity levels, while just 27% of those without safe places to walk were active enough.


Land Use Affects Our Level of Physical Activity – Continued

FACTS:

• Residents who move into more walkable neighborhoods will shift some trips to transit, bicycling and walking as a result.
• People living in sprawling, low-density counties walk less, weigh more and are more likely to be obese or have hypertension than people living in more compact counties.

Land Use Affects Our Level of Physical Activity – Continued

FACTS:

• Sprawl is a significant risk factor for traffic fatalities, especially for pedestrians (Ewing et al. 2003b)

• Sprawl is positively associated with obesity, BMI and hypertension (Ewing et al. 2003a)

• Poor access to sidewalks, recreational facilities, walk or cycle paths, and shops within walking distance are positively associated with a greater likelihood of being either overweight or obese (Giles-Corti et al. 2003)
Physical Inactivity & Obesity Linked to Sprawl & Auto-Dependence

- Today, Americans spend 25.5 minutes in their cars commuting to work (a 13.8% increase).
- Each additional hour spent in a car per day is associated with a 6% increase in the likelihood of becoming obese.
- Each additional kilometer (0.62 miles) walked per day is associated with a 4.8% reduction in the likelihood of becoming obese.
- Land-use mix – the extent to which a community is comprised of residential, commercial, office, and institutional land uses – has the strongest association with obesity, with each quartile increase being associated with a 12.2% reduction in the likelihood of obesity (across gender and ethnicity).
- Land-use mix is a good predictor of pedestrian travel.

Health Care Cost Burdens

Developmental Policy & Health Favorability Status
How favorable is the health status of your labor pool?

Report Finds Kentucky Has 6th Highest Rate of Adult Obesity in U.S.

“‘To be more prosperous, the state must get healthier.’

-- Gov. Ernie Fletcher

“The poor health of Kentuckians drives up medical costs, he said, which can make the state less attractive to businesses and less competitive with nearby states.”

**Results: Capital Investment Health Impact Assessment**

Based on a comparison of your input with known data, physical inactivity is costing your business or community an estimated $3,800,257,420 per year. That’s about $1,202 per person.

- Medical Care Costs: $576,884,157
- Workers Comp Costs: $12,364,017
- Lost Productivity Costs: $3,209,009,246
- Total Costs: $3,800,257,420

If as little as 5% of inactive people in your business or community became physically active, it could save an estimated $190,012,871 per year.
Productivity Burdens to U.S. Businesses

- **Cost of obesity to U.S. businesses** among employees aged 25-64 years is estimated to total more than **$13 billion annually** in medical fees and lost productivity associated with disability-related absences and is **associated with 39 million lost workdays**.
- **Average absence** for a worker who files an obesity-related disability claim is **45 days**.
- Obese employees are **nearly two times more** likely to experience high levels of **absenteeism** than are non-obese employees.
- Obesity-attributable business expenditures on paid sick leave, life insurance, and disability insurance amount to **$5 billion**.
- **Diabetes, arthritis, and heart disease are linked to obesity**, which cost employers more than **$220 billion annually** in medical care and lost productivity.
- Employee absences resulting from obesity adversly affect businesses due to rising healthcare costs, lost productivity, the increase burden on other workers, and the cost of training a replacement employee or paying overtime to other employees to compensate for the lost work hours.
Housing Quality

*Economic Impact of Hazards Exposure: The case of lead (Pb)*
# Prediction Modeling

## Initial Elevated Likelihood Measures (ELMs)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Thresholds</th>
<th>Odds Ratios</th>
<th>p-value</th>
<th>Multivariate (0.97 - 0.18^3)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>% pre1950 Housing</td>
<td>L¹ 27% U² 60%</td>
<td>Bivariate</td>
<td>&lt; .001</td>
<td>1.474</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>% Poverty</td>
<td>40% 72%</td>
<td>1.436</td>
<td>&lt; .001</td>
<td>1.606</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>% NonWhite Race</td>
<td>36% 68%</td>
<td>1.571</td>
<td>&lt; .001</td>
<td>0.977</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>% Prevalence</td>
<td>12% 44%</td>
<td>1.024</td>
<td>&lt; .001</td>
<td>2.249</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Year Built</td>
<td>1896 - 1946</td>
<td>1.035</td>
<td>&lt; .001</td>
<td>2.157</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>House Value</td>
<td>20,916 – 64,506</td>
<td>1.000</td>
<td>&lt; .001</td>
<td>1.349</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

1 50% likelihood of becoming elevated  
2 100% likelihood of becoming elevated  
3 Cox & Snell/Nagelkerke R-square

Leveraging your model to affect housing policy…
Geocoding & Address Verification at Vital Event

Street Address: 808 Woodberry Rd, Lexington, SC, 29073

Latitude: 33.98561818
Longitude: -81.13887273
Surveillance of High Risk Threshold Areas
Repeat Offender Housing
Upper Threshold High Risk Area
Proportion of Highest Risk Housing by Unit Type in Identified Upper Threshold ELM Area

Number of At-Risk Units: 439
Number of EBLL(≥10μ/dL) Units: 55
Number of Repeat Offender Units: 4 (7.3% of EBLL)
Type of Units: Single Family
Mean House Value: $34,834 USD
Median Year Built: 1920
Mean Blood Lead Level: 14.3 mcg/dL
WARNING!
This house is hazardous to families with young children and may be unfit for human habitation.

Policy Impact:
- ↑ Cross Functional Programming
- ↑ Resource Leveraging
- ↑ Housing Quality
- Economic Impact...
Estimated cost impact to Kentucky
Earnings and tax revenue loss

- $54.9 billion – annual cost of environmentally attributable diseases
- $43.4 billion arise from lead poisoning (79%)³-⁵

- $3,720 - $9,500 earnings loss/IQ point (≥ 10 μg/dL)

- #children in KY aged 1-2 years with ≥ 10 μg/dL = 780/year (2000-2002 average – 6% testing rate)
- Estimated annual earnings gain/loss - $34.8 - $88.9 million (assuming a 6% testing rate)
- Estimated annual earnings gain/loss if achieved 25% national testing rate - $145.2 - $370.8 million
- Estimated tax gain/loss: $42.1 - $107.5 million (assuming 29% deductions)

⁴ EPA, 1996. TSCA Title IV, Sections 402(a) and 4040: target housing and child-occupied facilities final rule regulatory impact analysis. Prepared by ABT Associates
Estimated impact to Kentucky
Average remediation costs

- $1,000 - $40,000/unit (lead-safe/lead-free)
  - $1,000/unit interim control (average)
  - $9,000/unit full abatement (average)

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1 President’s Task Force on Environmental Health Risks and Safety Risks to Children. Eliminating Childhood Lead Poisoning: A Federal Strategy Targeting Lead Paint Hazards (February 2000);
Estimated number of pre-1960 housing units in Kentucky at risk of having lead paint hazards in 2010

<table>
<thead>
<tr>
<th>Housing Stock</th>
<th>Number of Housing Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total estimated units at risk of lead paint hazards in 1999 (owner/renter-occupied)</td>
<td>478,423</td>
</tr>
<tr>
<td>Reduction due to demolition, 2000-2010 (est.)</td>
<td>-35,882</td>
</tr>
<tr>
<td>Reduction due to substantial renovation, 2000-2010 (est.)</td>
<td>-75,590</td>
</tr>
<tr>
<td>Subtotal (Total estimated units at risk of lead paint hazards in 2010)</td>
<td>366,951</td>
</tr>
<tr>
<td>20% of subtotal occupied by low-income families at highest risk of lead paint hazards exposure</td>
<td>73,390</td>
</tr>
</tbody>
</table>

Estimated average direct annual costs of options to address lead paint in pre-1960 housing stock in Kentucky, 2001-2010

<table>
<thead>
<tr>
<th>Pre-1960 Housing Stock</th>
<th>Lead Hazard Screening and Interim Controls ($1,000 per unit)</th>
<th>Inspection/Risk Assessment and Full Abatement of Lead Paint ($9,000 per unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All pre-1960 housing with lead paint (36,695/year)</td>
<td>$36.7 million</td>
<td>$330.2 million</td>
</tr>
<tr>
<td>Pre-1960 housing occupied by families living below poverty (7,340 units/year)</td>
<td>$7.3 million</td>
<td>$66.1 million</td>
</tr>
</tbody>
</table>

Estimates derived from the Evaluation of the HUD Lead-Hazard Control Grant Program: Economic Analysis for the HUD Lead Paint Regulation for Federally Assisted Housing.
Making the case for statewide remediation

- Cost of remediation per year over 10 years
  - Range: $7.3 million (interim controls) - $66.1 million (full abatement)
- Loss of lifetime earnings each year
  - $145 - $370 million/year due to ↓ productivity
  - only addresses children aged 1-2 years with BLL ≥ 10 μg/dL
- Tax revenue lost each year by the Commonwealth of Kentucky
  - $42.1 – 107.5 million/year
  - Includes only children aged 1 – 2 years
- Related cost savings in Health Care, Special Education, Criminal Justice, and Legal Liability
Investigating Features that Promote Health in the Built Environment
Features That Promote Physical Activity & Health

• Accessibility
  – cycle path; destinations within walking distance; density/convenience of recreational facilities; public attractive open space

• Opportunities for activity
  – sidewalk presence, trails

• Neighborhood perceptions / aesthetics
  – overall walking quality, emotional satisfaction with neighborhood, satisfaction with neighborhood services (access to transit system and to shopping); enjoyable scenery; street connectivity

• Safety
  – perceived safety, streetlights; perceived heavy traffic (barrier to PA); perceived busy street to cross (barrier to PA)
Modifiable Built Environment Factors That Influence Physical Activity & Health

- **Land Use Mix**
  - Promotes more opportunities to walk and use transit; for trips less than 1 mile, mixed use communities generate up to 4-times as many walk trips.

- **Network Connectivity**
  - Poor network (street) connectivity reduces pedestrian mobility and trips; as the number of intersections and blocks increase, the number of walk trips increase; as the number of cul-de-sacs and loops increase, the number of walk trips decrease.

- **Street Design**
  - Addresses the quality of the street to support walking and bicycling. Amenities include trees, crosswalks, sidewalks, bikeways. Calms or discourages traffic and encourages pedestrian presence.

- **Site Design**
  - Design features that promote walk/bike trips include short building set backs and neighborhood parks and green space.

- **Density**
  - Appropriate residential and employment density (> 7 units and 100 employees per acre) are associated with increased walk, bike, and transit trips.
Design Specifications

“There’s metrics in them there plans!”
Prescribing Design: Design Typologies & Their Principles

- The Neighborhood Unit
- The Garden City
- Transit-Oriented Design (TOD)
- Neotraditional/New Urbanist Design
The Neighborhood Unit

- 1,000 – 5,000 residents
- 160 acres
- Density = 10 families/acre
- One-half mile walk rule
- Interior street patterns
- Pedestrian paths
- Central common and green
- Shopping facilities, churches, library, community center located near elementary school centrally located
- Examples
  - Reston, Virginia
  - Columbia, Maryland
The Garden City

- Total area of city – 6,000 acres
- Developed (built) area – 1,000 acres
- Permanent greenbelt – 5,000 acres
- Total population – 32,000
- City organization
  - Center – civic buildings
  - 1\textsuperscript{st} ring – central park
  - 2\textsuperscript{nd} ring – housing a various typed
  - 3\textsuperscript{rd} ring – crystal palace or covered promenades
  - 4\textsuperscript{th} ring – factories and warehouses
  - Greenbelt – permanent open space
- Examples
  - Letchworth, Welwyn – UK
  - Greenbelt, Maryland
  - Greenhills, Ohio
  - Greendale, Wisconsin
Transit-Oriented Development (TOD)

- 50 – 100 acres (smaller than a New Town; larger than a PUD)
- 2,000 dwelling units
- 1 million sq. ft. commercial and employment activities
  - 750,000 sq. ft. office space
  - 60,000 sq. ft. neighborhood shopping
  - 1,000 sq. ft. parking places
- 400 units of townhouses/duplexes
- 50-single family detached dwellings
- 150 units of elderly facilities
- 2 day-care centers
- Community facilities – police station, fire house, town hall, post office, library, and religious establishments
- 12 acres of parks and recreation facilities
- Mixed income/household types
- Light rail station
- Examples – Laguna West, Sacramento CA; Vista West, San Diego CA; Merced Villages, Merced CA; Dry Creek Ranch, Sacramento CA; South Brentwood Village, Brentwood CA; Northwest Landing, Tacoma WA; Lexington Park, Polk County FL
Neotraditional/New Urbanist Design

- Quarter-mile (5-minute) walk orientation
- Primary orientation to public transit, rather than private automobile
- Mixed land uses – housing, shops, workplaces, schools, parks, civic facilities
- Mixed income
- Center focus for commercial, civic, cultural, recreational uses
- Specialized open space – squares, greens, parks
- Well-defined edges – greenbelts, wildlife corridors
- Streets, pedestrian paths, bike paths fully connected and intersecting routes to all destinations
- Energy-, water-, waste-efficient community design
- Examples: Seaside, FL; Harbor Town, TN; Celebration, FL; Kentlands, Maryland
Developing and Translating Metrics into Policy Solutions

What we know…

+ Clinical Dose-Response Relationships
+ Economic Impact
+ Modifiable Features
+ Design Specifications

= We Need Enhanced Design and Health Impact Assessment Tools

…connecting to dots
Developing GIS-based Planning & Design Tools
Planning Support Systems for Simulation and Scenario Modeling

- METROPILUS
  - Urban models and GIS
- Tranus
  - Integrated land-use and transport modeling
- CUF, CUF II, CURBA
  - Urban growth and land-use policy simulation models
- UrbanSim
  - Decision-support system for Metropolitan planning
- INDEX
  - Community indicators
- What if?
- Community Viz
  - Integrated planning support
CommunityViz provides GIS-based analysis and real-world 3D modeling that allow people to envision land use alternatives and understand their potential impacts, explore options and share possibilities, and examine scenarios from all angles — environmental, economic, and social.
**Planning Support System**

- **INDEX** is a suite of interactive GIS planning tools that measure existing conditions, evaluate alternatives, and support implementation of adopted plans.

- **Land-Use**
- **Housing**
- **Employment**
- **Transportation**
- **Infrastructure**
- **Environment**
- **Amenities proximity**
- **Energy consumption**
  - Housing
  - Employment
  - Transportation
  - Greenhouse gases

- **Street connectivity**
- **Non-point source pollution**
- **Watersheds**
- **Air quality**
  - Carbon monoxide
  - Hydrocarbon
  - Oxides of sulfur
  - Oxides of nitrogen
  - Particulate matter
  - Carbon dioxide

- **Pedestrian suitability**
- **Stormwater runoff evaluation**
A New Paradigm?

• Using Planning and Design “Prescriptions” to Promote Healthy Living as a Routine Part of our Daily Lives...

• …May Be a Better Public Health Policy Strategy Than Conventional Structured and Organized Programs.

Health by Design!
Final Thoughts
Consider this:

All the ants on the planet, taken together, have a biomass greater than that of humans. Ants have been incredibly industrious for millions of years. Yet their productiveness nourishes plants, animals, and soil. Human industry has been in full swing for little over a century, yet it has brought about a decline in almost every ecosystem on the planet. Nature doesn’t have a design problem. People do.

— William McDonough
Cradle to Cradle, p. 16
Thank you.