A population health science perspective on health in cities

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54% of the world’s population currently lives in urban areas, and another 2.5 billion people are expected to be added to urban populations by 2050, surpassing 6 billion
More than 50% of the population is living in urban areas, 1960
More than 50% of the population is living in urban areas, 1970
More than 50% of the population is living in urban areas, 1980

More than 50% of the population is living in urban areas, 1990
More than 50% of the population is living in urban areas, 2000
More than 50% of the population is living in urban areas, 2010
More than 50% of the population is living in urban areas, 2020

More than 50% of the population is living in urban areas, 2030

More than 50% of the population is living in urban areas, 2040

More than 50% of the population is living in urban areas, 2050
More rapid urbanization is occurring in low-income regions.

The total population of the ten largest cities in the world...

1. Shanghai
2. Beijing
3. Karachi
4. Shenzhen
5. Guangzhou
6. Mumbai
7. Istanbul
8. Moscow
9. Sao Paulo
10. Kinshasa
...is larger than all but the 15 largest countries in the world
The Gross Metropolitan Product of the top 10 metro areas in the U.S. in 2012 exceeded the combined output of 36 states.

<table>
<thead>
<tr>
<th>Total Gross Metro Product:</th>
<th>$5.34 trillion</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York-Northern New Jersey-Long Island, NY-NJ-PA</td>
<td></td>
</tr>
<tr>
<td>Los Angeles-Long Beach-Santa Ana, CA</td>
<td></td>
</tr>
<tr>
<td>Chicago-Joliet-Naperville, IL-IN-WI</td>
<td></td>
</tr>
<tr>
<td>Houston-Sugar Land-Baytown, TX</td>
<td></td>
</tr>
<tr>
<td>Washington-Arlington-Alexandria, DC-VA-MD-WV</td>
<td></td>
</tr>
<tr>
<td>Dallas-Fort Worth-Arlington, TX</td>
<td></td>
</tr>
<tr>
<td>Philadelphia-Camden-Wilmington, PA-NJ-DE-MD</td>
<td></td>
</tr>
<tr>
<td>San Francisco-Oakland-Fremont, CA</td>
<td></td>
</tr>
<tr>
<td>Boston-Cambridge-Quincy, MA-NH</td>
<td></td>
</tr>
<tr>
<td>Atlanta-Sandy Springs-Marietta, GA</td>
<td></td>
</tr>
</tbody>
</table>

Ten most populated urban areas in the world
All cities in the world occupy about 1% of the world’s land surface, and >50% of the people
The heterogeneity of urban spaces
Boston T-stops
Percent of adults with diabetes by T stop, 2010

- If you get off at Arlington: 3%
- If you get off at Mattapan: 10%
- If you get off at Maverick: 11%
- If you get off at Dudley Square: 11%
- If you get off at Fenway: 2%

Percent of residents 25+ years old with a bachelor's degree or more by T stop, 2006-2010

If you get off at Arlington: 79%
If you get off at Mattapan: 16%
If you get off at Maverick: 16%
If you get off at Dudley Square: 25%
If you get off at Fenway: 71%

Percent of adults who get regular physical activity by T stop, 2010

If you get off at Arlington: 68%

If you get off at Mattapan: 50%

If you get off at Maverick: 48%

If you get off at Dudley Square: 51%

If you get off at Fenway: 68%

...despite the fact that the geographic distance between these areas is so small...

...and despite the fact that they do not differ greatly on geographic closeness to health services
In Detroit, amongst the most segregated cities in America, 8 Mile Road serves as a sharp racial dividing line.

*Image: Dustin Cable*
Understanding cities and health
FIGURE 1. The power of the prevailing paradigm: drawing of an Australian kangaroo by a sixteenth-century Dutch artist (Cornelis de Jode), based on descriptions by early explorers.
Fig. 1. A conceptual framework for Urban Health. Because of the complexity of the potential relations among the determinants of health of urban populations, our framework of necessity simplifies a number of potential relations between the domains shown here and discussed in the manuscript. A more detailed description of some of the plausible relations between key variables in the conceptual framework is provided in the text. We also note that the arrows in the figure are purely schematic and do not mean to be exhaustive or definitive. There are several interrelationships between the domains presented here and we would anticipate that most relationships would be multidirectional. This pictorial representation of the framework discussed in the text also is limited by its static nature. A fuller depiction of the determinants of the health of urban populations would incorporate the changes over time (e.g., growing city population) that in and of themselves are important determinants of health.
“Population health science is the study of the conditions that shape distributions of health within and across populations, and of the mechanisms through which these conditions manifest as the health of individuals.”
1. Population health manifests as a continuum.
2. The causes of differences in health across populations are not necessarily an aggregate of the causes of differences in health within populations.
3. Large benefits to population health may not improve the lives of all individuals.
4. The causes of population health are multilevel, accumulate throughout the life course, and are embedded in dynamic interpersonal relationships.
5. Small changes in ubiquitous causes may result in more substantial change in the health of populations than larger changes in rarer causes.
6. The magnitude of an effect of exposure on disease is dependent on the prevalence of the factors that interact with that exposure.
7. Prevention of disease often yields a greater return on investment than curing disease after it has started.
8. Efforts to improve overall population health may be a disadvantage to some groups; whether equity or efficiency is preferable is a matter of values.
9. We can predict health in populations with much more certainty than we can predict health in individuals.
Principle 5. Small changes in ubiquitous causes may result in more substantial change in the health of populations than larger changes in rarer causes.
The goldfish are surrounded by water and everything they do is influenced by the quality of the water in which they live; therefore, water is a ubiquitous factor influencing the fish and needs to be taken into consideration every time we may want to improve the lives of the fish.
For Decades, the Richest Pulled Away...

Share of income for the:

- 20%
- Top 1%
- 15
- 10
- 5
- Top 1/10,000th

In 2007, 24% of income went to the 1.5 million families who earned more than $400,000.

Share of income for the bottom 90%:

- 65%
- 60
- 55
- 50

In 2007, 50% of income went to the 135 million families who earned less than $110,000.
The prevalence of IV drug use is 1.96% and IV drug users have 6.25 times the risk of mortality compared with non-IV drug users. For every 100 IV drug users, we would expect 4.2 additional deaths.

Table 1. Five-year mortality for those 18-65 in country with high income inequality

<table>
<thead>
<tr>
<th></th>
<th># died</th>
<th># alive</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV drug user</td>
<td>50</td>
<td>950</td>
<td>1000</td>
</tr>
<tr>
<td>Non-IV drug user</td>
<td>400</td>
<td>49600</td>
<td>50000</td>
</tr>
<tr>
<td>Total</td>
<td>450</td>
<td>50550</td>
<td>51000</td>
</tr>
</tbody>
</table>

\[
RR = \frac{50}{1000} = \frac{400}{400} = 6.25
\]

\[
RD = \left( \frac{50}{1000} \right) - \left( \frac{400}{50,000} \right) = 0.042
\]
Suppose we reduce income inequality by 25%, keeping prevalence of IV drug use the same, but reducing excess mortality in all groups.

<table>
<thead>
<tr>
<th></th>
<th># died</th>
<th># alive</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV drug user</td>
<td>40</td>
<td>960</td>
<td>1000</td>
</tr>
<tr>
<td>Non-IV drug user</td>
<td>320</td>
<td>49680</td>
<td>50000</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td>50640</td>
<td>51000</td>
</tr>
</tbody>
</table>
Therefore, those in the unequal society had 1.25 times the risk of death, and we would expect 1.8 deaths per 1,000 persons exposed to the unequal society.
In the hypothetical income inequality intervention, we have “saved” 90 lives. In our IV drug use example, we would “save” a maximum of 42 lives even if all IV drug users stopped using.
Crack Babies: The Worst Threat Is Mom Herself

By Douglas J. Besharov

LAST WEEK in this city, Greater Southeast Community Hospital released a 7-week-old baby to her homeless, drug-addicted mother even though the child was at severe risk of pulmonary arrest. The hospital's explanation: "Because [the mother], demanded that the baby be released."

The hospital provided the mother with an apnea monitor to warn her if the baby stopped breathing while asleep, and trained her in CPR. But on the very first night, the mother went out drinking and left the child at a friend's house—without the monitor. Within seven hours, the baby was dead. Like Dooney Waters, the 6-year-old living in his mother's drug den, whose shocking story was reported in The Washington Post last week, this child was all but abandoned by family.
<table>
<thead>
<tr>
<th>Predictor for Peabody Picture Vocabulary Test score</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational cocaine exposure</td>
<td>-2.89</td>
<td>0.26</td>
</tr>
<tr>
<td>Assessment no.</td>
<td>2.72</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gestational cocaine exposure x assessment no.</td>
<td>0.58</td>
<td>0.51</td>
</tr>
<tr>
<td>Age at 1st assessment</td>
<td>-0.36</td>
<td>0.76</td>
</tr>
<tr>
<td>Female gender</td>
<td>-4.93</td>
<td>0.058</td>
</tr>
<tr>
<td>Parental nurturance</td>
<td>-0.31</td>
<td>0.89</td>
</tr>
<tr>
<td><strong>Environmental stimulation</strong></td>
<td><strong>5.91</strong></td>
<td><strong>0.039</strong></td>
</tr>
<tr>
<td>Caregiver BDI-II depression score</td>
<td>0.03</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Each time the Earned Income Tax Credit increases by 10 percent, infant mortality drops by 23.2 per 100,000.

https://www.cdc.gov/policy/hst/h15/taxcredits/index.html
Principle 6. The magnitude of an effect of exposure on disease is dependent on the prevalence of the factors that interact with that exposure.
How much of our obesity risk is determined by our genes?
= GE+

GE = genetic
ENV = environmental
OB = obese

= OB+

OB = obese
Scenario 1

GE = genetic; OB = obese; ENV = environmental
Scenario 1

GE = genetic; OB = obese; ENV = environmental
Scenario 1

RR (OB+|GE+) = 3.99
PARP (OB+|GE+) = 1

= GE+  = CA+  = ENV+
Scenario 2

GE = genetic; OB = obese; ENV = environmental
Scenario 2

= GE+  = OB+  = ENV+

GE = genetic; OB = obese; ENV = environmental
Scenario 2

RR (OB+|GE+) = 1.7
PARP (OB+|GE+) = 0.4

= GE+  = OB+  = ENV+
Therefore under a very plausible assumption of co-occurring causes, the gene-obesity association can only be understood if we understand the urban factors that distinguish between samples.
Is this all theoretical?
Figure 3. Predicted body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, as a function of residualized age- and sex-specific ln-transformed physical activity accelerometer counts according to FTO rs1861868 genotypes. On the left side of the plot (low physical activity), BMI levels are strikingly dissimilar between rs1861868 genotypes. In contrast, on the right side of the plot, similar BMI levels can be seen across genotypes, particularly in subjects with very high levels of physical activity.
Financial support for habitable homes: After rehabilitating housing 62% of adults have excellent health vs 33% before.

https://www.flickr.com/photos/nodding_pig/15588502793/sizes/l
Principle 1. Population health manifests as a continuum
Figure 1. Distribution of BMI in two populations illustrating health as a continuum in the population.
BMI = body mass index
Figure 3  Percentage distribution of serum cholesterol levels (mg/dl) in men aged 50–62 who did or did not subsequently develop coronary heart disease (Framingham Study\textsuperscript{5})

CHD = coronary heart disease
### Table

<table>
<thead>
<tr>
<th></th>
<th>Non-diseased</th>
<th>Diseased</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unexposed</td>
<td>A</td>
<td>B</td>
<td>A+B</td>
</tr>
<tr>
<td>Exposed</td>
<td>C</td>
<td>D</td>
<td>C+D</td>
</tr>
<tr>
<td>Total</td>
<td>A+C</td>
<td>B+D</td>
<td>N</td>
</tr>
</tbody>
</table>

### Figure 3

Percentage distribution of serum cholesterol levels (mg/dl) in men aged 50–62 who did or did not subsequently develop coronary heart disease (Framingham Study).

Comprehensive workplace-based obesity prevention programs that lower weight by 5% save $90 per person.
Principle 8. Efforts to improve overall population health may disadvantage some groups; whether equity or efficiency is preferable is a matter of values.
Figure 1. Gaining overall population health while increasing health inequity

**No intervention**
- DALY = 50
- DALY = 25

**Inequality of 25 DALY**

**Intervention adding 1 DALY**
- DALY = 51
- DALY = 25.5

**Inequality of 25.5 DALY**

**Intervention adding 10 DALY**
- DALY = 60
- DALY = 30

**Inequality of 30 DALY**

DALY = disability adjusted life years
Figure 2. Gaining overall population health while creating health inequalities

Before intervention

<table>
<thead>
<tr>
<th>High SES</th>
<th>Low SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DALY = 50</td>
<td>DALY = 50</td>
</tr>
<tr>
<td>No inequality</td>
<td>Inequality of 5 DALY</td>
</tr>
</tbody>
</table>

After intervention

<table>
<thead>
<tr>
<th>High SES</th>
<th>Low SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DALY = 60</td>
<td>DALY = 55</td>
</tr>
</tbody>
</table>

DALY = disability adjusted life years; SES = socioeconomic status
In a city of a million residents, 40 percent expansion of transit developments has annual health benefit of $216 million

Towards improving the health of urban populations
Mount Pleasant, South Carolina

Existing conditions: high speed center road with local serving side roads
Mount Pleasant, South Carolina

New sidewalks, one-way local access lane, parking lane, street lamps
Mount Pleasant, South Carolina

New infill development at sidewalks
Mount Pleasant, South Carolina

Palmetto trees in median
Mount Pleasant, South Carolina

Street trees on far side
Mount Pleasant, South Carolina

Street trees on near medians
Mount Pleasant, South Carolina

Street trees on near side
Mount Pleasant, South Carolina

Increased street life
Mount Pleasant, South Carolina

Light rail in median
Mount Pleasant, South Carolina

Residential development alternative
A healthy city is one that continually creates and improves its physical and social environments and expands the community resources that enable people to mutually support each other in performing all the functions of life and developing to their maximum potential.

EXECUTIVE SUMMARY

The Urban Health Penalty

New Dimensions and Directions in Inner-City Health Care

Introduction

For many years, inner cities have presented major challenges to communities, health care providers and their governments. Violence, poverty and other social ills are often perceived as fates suffered by residents of inner-city neighborhoods, and many agree that populations in those settings face the greatest challenges to health and survival in the United States. Yet few studies have been done to...
Urban Health

Toward an Urban Health Advantage

David Vlahov, Sandro Galea, and Nick Freudenberg

For many years, inner cities have presented major challenges to communities, health care providers and their governments. Violence, poverty and other social ills are often perceived as fates suffered by residents of inner-city neighborhoods, and many agree that populations in those settings face the greatest challenges to health and survival in the United States. Yet few studies have been done to
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