Persistent spatial clusters of high body mass index in a Swiss urban population as revealed by the 5-year GeoCoLaus longitudinal study

Joost S¹, Duruz S¹, Marques-Vidal P², Bochud M³, Stringhini S³, Paccaud F³, Gaspoz JM⁴, Theler JM⁴, Chételat J⁵, Waeber G², Vollenweider P², Guessous I³, 4, 6, 7

1 Swiss Federal Institute of Technology (EPFL); 2 Lausanne University Hospital (CHUV); 3 Institute of Social and Preventive Medicine (IUMSP); 4 Division of Primary care, Geneva University Hospitals; 5 MicroGIS, Lausanne; 6 Lausanne, University Outpatient Clinic Lausanne University Hospital; 7 Rollins School of Public Health, Emory University, USA
Obesity

Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants

NCD Risk Factor Collaboration (NCD-RisC)*
Lancet 2016; 387: 1377–96

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>1975</td>
<td>1975</td>
</tr>
<tr>
<td>Mean BMI</td>
<td>21.7 kg/m²</td>
<td>22.1 kg/m²</td>
</tr>
<tr>
<td>Obesity prevalence</td>
<td>3.2%</td>
<td>6.4%</td>
</tr>
<tr>
<td>2014</td>
<td>24.2 kg/m²</td>
<td>24.4 kg/m²</td>
</tr>
<tr>
<td></td>
<td>10.8%</td>
<td>14.9%</td>
</tr>
</tbody>
</table>
Intake > Output
Obesity System Influence Diagram

Full Map

Clusters
Core Loop
Individual Psychology
Social Psychology
Individual Activity
Activity Environment
Food Consumption
Food Production
Individual Physiology
Physiology

Social Psychology
Individual Psychology
Physical Activity Environment
Food Consumption
Food Production
Individual Physiology
Physiology

EYGY BALANCE

Negative Influence
Positive Influence
Media
Social
Psychological
Fiscal
Food
Activity
Policies
Environments
Indirect
Direct
Urban environment & CVD

Diez Roux AV. J Urban Health 2003;80(4): 569-89

Physical environment

Accessibility of recreational resources → Sport and leisure time physical activity
Transportation, sidewalks, bike lanes → Walking
Design of public spaces
Land use, density, street connectivity, and urban form
Aesthetic quality → Stress and psychosocial factors
Availability and relative cost of “healthy” foods → Diet
Food and tobacco advertising → Smoking
Availability of tobacco
Noise → Sleep disturbance and stress
Air pollution

Social environment

Safety and violence → Stress and psychosocial factors
Social support and cohesion
Social norms → Behaviors (diet, physical activity, smoking)

Proximate biological factors
Blood pressure
Body mass index
Diabetes
Blood lipids
Stress response
Others

Clinical cardiovascular disease
Inflammation
Endothelial function
Heart rate variability
Arrhythmia

Social environment and Network

The Spread of Obesity in a Large Social Network over 32 Years

Nicholas A. Christakis, M.D., Ph.D., M.P.H., and James H. Fowler, Ph.D.
http://www.hug-ge.ch/medecine-premier-recours/giraph
Persistent spatial clusters of high body mass index in a Swiss urban population as revealed by the 5-year GeoCoLaus longitudinal study

Stéphane Joost, Solange Duruz, Pedro Marques-Vidal, Murielle Bochud, Silvia Stringhini, Fred Paccaud, Jean-Michel Gaspoz, Jean-Marc Theler, Joël Chételat, Gérard Waeber, Peter Vollenweider, Idris Guessous

BMJ Open 2016;6:e010145
PMID 26733572
Colaus Study location and altitude of participants (n=6705)
- Geocolaus data
- Municipality of Lausanne, without zones foraines (urban area only)

Base, N = 6’481
Follow-up, N = 4’493

CoLaus1 study=2003-6; CoLaus 2 study=2009-12
Spatial dependence

- Define a given spatial lag: e.g., distance (100m around each dot) or number of dots
Define a given spatial lag: e.g., distance (100m around each dot) or number of dots.

Use this spatial lag to calculate for each dot the weighted indice \((\text{Neighbor1} + \text{Neighbor2} + \text{Neighbor3})/3\) and compare it to the index dot.
Define a given spatial lag: e.g., distance (100m around each dot) or number of dots

Use this spatial lag to calculate for each dot the weighted indice \((\text{Neighbor1} + \text{Neighbor2} + \text{Neighbor3})/ 3\) and compare it to the index dot

Indication on the relationship between the index dot and the weighted index
Standardized scattergram

Moran's I = 0.4251

High-High

Low-Low

Population mean BMI
Statistics

Gi statistic, standardized Z score

Statistical significance testing based on a randomization procedure using a sample of 999 permutations + Bonferroni/Sidak procedure to correct for multiple comparisons

Large significant positive Z scores reveal intense clustering of high values (red dots)

Large significant negative Z scores reveal intense clustering of low values (blue dots)

Analyzed the BMI variables within 800 meters around each individual’s postal address
Models (Neighbourhood vs Individual)

- Unadjusted

- **Neighbourhood-level income:**
  Adjusted for 2009 neighbourhood-level median income

- **Individual socioeconomic and demographic status:**
  Further adjusted for age, sex, education level, Caucasian ethnicity, marital status, government benefits, physical activity, smoking status, and alcohol consumption
Among the 6733 participants at baseline, 252 (3.7%) were excluded because they lived in municipal districts in the countryside, and 17 (0.25%) could not be geocoded.

Thus, 6481 (96%) participants living in the urban area of Lausanne were geocoded using their postal address (geographic coordinates of the residence).
Getis-Ord Gi clustering
Baseline, raw BMI [6481]
- 0 - no spatial dependence [2935]
- 1 - high (Z-score ≥ 1.96) [1224]
- 2 - low (Z-score ≤ 1.96) [2322]

Spatial lag = 800m
Significance level: p < 0.05 (999 permutations)

Unadjusted
Getis-Ord Gi clustering
Baseline, median income adj. BMI [6481]

- 0 - no spatial dependence [4319]
- 1 - high (Z-score ≥ 1.96) [968]
- 2 - low (Z-score ≤ 1.96) [1194]

Spatial lag = 800 m
Significance level: p < 0.05 (999 permutations)

Adjusted for neighbourhood income
Getis-Ord Gi clustering
Baseline, BMI adj. for all SES variables [6481]

- 0 - no spatial dependence [5092]
- 1 - high (Z-score ≥ 1.96) [771]
- 2 - low (Z-score ≤ 1.96) [618]

Spatial lag = 800m
Significance level: p < 0.05 (999 permutations)

Adjusted for neighbourhood income and individual factors
CoLaus 5-year follow-up:

Among the 5064 participants at follow-up, 604 (12%) were excluded because they had moved outside the urban limits of the Lausanne municipality between 2006 and 2009.

Thus, 4460 (88%) participants could be geocoded at follow-up.
A comparison of the spatial dependence of body mass index among adults and children in a Swiss general population

I Guessous\textsuperscript{1,2,6}, S Joost\textsuperscript{3,6}, E Jeannot\textsuperscript{4,5}, J-M Theler\textsuperscript{1}, P Mahler\textsuperscript{5}, J-M Gaspoz\textsuperscript{1} and the GIRAPH Group\textsuperscript{7}
6663 Adults
(Bus Santé study)

Unadjusted
Limitations

Participation bias cannot be excluded

Data on individual income was missing

Residual confounding

Analyzed within 800 meters around each individual’s postal address. We tested 8 other spatial lags (400; 600; 1,000; 1,200; 1,400; 1,600; 1,800 and 2,000 meters), results were consistent
Conclusions

First study to explore longitudinal changes in the spatial distribution of BMI, the spatiotemporal approach proposed here identified persistent clusters with high BMI.

High BMI clusters that persisted after adjustment for individual-level and neighbourhood income deserve to be further considered as they might be related to other obesogenic factors such as the food environment.

Need to better understand the causes of such clustering, both at the individual level and at the structural level, and to plan interventions aiming at modifying these determinants.

Thank you!

http://epidemiologiepopulation.hug-ge.ch

idris.guessous@hcuge.ch
stephane.joost@epfl.ch

/Bus Santé
Table 1. Neighborhood Measures for Healthy Food and PA Resources and Social Environments

<table>
<thead>
<tr>
<th>Neighborhood Summary and Component Measures</th>
<th>Scale^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy food environment summary score</td>
<td>Sum of standardized component measures</td>
</tr>
<tr>
<td>GIS-based density of supermarkets and/or FV markets</td>
<td>No. of food stores likely to sell healthier foods (supermarkets, FV markets) per square mile</td>
</tr>
<tr>
<td>Survey-based healthy food availability</td>
<td>Likert scale, 1-5 (eg, “A large selection of fresh fruits and vegetables is available in my neighborhood.”)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PA environment summary score</th>
<th>Sum of standardized component measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS-based density of commercial recreational establishments</td>
<td>No. of commercial recreational establishments (gym, pools, etc) per square mile</td>
</tr>
<tr>
<td>Survey-based walking environment</td>
<td>Likert scale, 1-5 (eg, “My neighborhood offers many opportunities to be physically active.”)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social environment summary score</th>
<th>Sum of standardized component measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey-based social cohesion</td>
<td>Likert scale, 1-5 (eg, “People in my neighborhood can be trusted.”)</td>
</tr>
<tr>
<td>Survey-based safety</td>
<td>Likert scale, 1-5 (eg, “I feel safe walking in my neighborhood, day or night.”)</td>
</tr>
</tbody>
</table>

Abbreviations: FV, fruit and vegetable; GIS, geographic information system; PA, physical activity; T2DM, type 2 diabetes mellitus.

^a Data are from the Neighborhood Multi-Ethnic Study of Atherosclerosis, 2000 to 2012.25

^b All measures are constructed such that higher values indicate more favorable environments.
<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Densité de population</th>
<th>Densité d'emplois</th>
<th>Code.</th>
<th>Desserte TP</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 1</td>
<td>Grands centres</td>
<td>Forte</td>
<td>Forte</td>
<td>1</td>
<td>Excellente</td>
<td>Nombreux</td>
</tr>
<tr>
<td>- 5</td>
<td>Communes à revenu élevé</td>
<td>Faible</td>
<td>Faible</td>
<td>5</td>
<td>Médiocre</td>
<td>Rares</td>
</tr>
<tr>
<td>- 9</td>
<td>Communes d'emploi</td>
<td>Moyenne-forte</td>
<td>Forte</td>
<td>9</td>
<td>Bonne</td>
<td>Nombreux</td>
</tr>
<tr>
<td>- 10</td>
<td>Communes suburbaines</td>
<td>Moyenne-faible</td>
<td>Moyenne</td>
<td>10</td>
<td>Moyenne</td>
<td>Assez nombreux</td>
</tr>
<tr>
<td>- 11</td>
<td>Communes périurbaines</td>
<td>Faible</td>
<td>Faible</td>
<td>11</td>
<td>Médiocre</td>
<td>Rares</td>
</tr>
<tr>
<td>- 15</td>
<td>Communes de pendulaires</td>
<td>Faible</td>
<td>Faible</td>
<td>15</td>
<td>Médiocre</td>
<td>Rares</td>
</tr>
<tr>
<td>- 20</td>
<td>Communes agro-tertiaires</td>
<td>Faible</td>
<td>Faible</td>
<td>20</td>
<td>Médiocre</td>
<td>Rares</td>
</tr>
</tbody>
</table>
Obesity and income Bus Santé

Obésité %

Revenus mensuels bruts du ménage  SFr

- jusqu'à 2'999
- de 3'000 à 4'999
- de 5'000 à 6'999
- de 7'000 à 9'499
- de 9'500 à 13'000
- plus que 13'000
BMI: LISA for different numbers of neighbors

- 30 neighbors
- 40 neighbors
- 50 neighbors

Legend:
- Not Significant
- High-High
- Low-Low
- Low-High
- High-Low
3601 schoolchildren

Unadjusted
Adjusted for neighbourhood income
GENÈVE

L'obésité, miroir des inégalités

2-3 En constante augmentation, le phénomène de surpoids dépend de notre environnement. À Genève, il reflète les inégalités sociales, dont les enfants font particulièrement les frais. C'est ce que suggère un récent rapport.
## Urban Health

<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Li, Harmer et al. 2009)</td>
<td>Oregon, USA</td>
<td>Neighborhoods with high walkability decrease the risk of hypertension</td>
</tr>
<tr>
<td>(Baccarelli, Martinelli et al. 2009)</td>
<td>Lombardia, Italy</td>
<td>Living near major traffic roads is associated with increased risk of DVT</td>
</tr>
<tr>
<td>(Kan, Heiss et al. 2008)</td>
<td>North Carolina, Mississippi, Minneapolis, and Washington County, USA</td>
<td>Traffic-related air pollution increases the risk of coronary heart disease in middle-age persons</td>
</tr>
<tr>
<td>(Diez Roux 2003)</td>
<td>Review 2003</td>
<td>Socioeconomically disadvantaged neighborhoods is associated with higher prevalence of coronary heart disease, hypertension, obesity and dyslipidemia (persists after controlling for income, education, and occupation)</td>
</tr>
<tr>
<td>(Humpel, Owen et al. 2002)</td>
<td>Systematic review</td>
<td>Accessibility of facilities, opportunities for activity, and aesthetic qualities of the area favor physical activity</td>
</tr>
<tr>
<td>(Weich, Blanchard et al. 2002)</td>
<td>London, UK</td>
<td>Neighborhood environments affect social support and depression which are two psychosocial factors for cardiovascular disease</td>
</tr>
<tr>
<td>(Stansfeld, Haines et al. 2000)</td>
<td>Narrative review</td>
<td>Traffic noise is associated with elevated blood pressure and risk of myocardial infarction</td>
</tr>
<tr>
<td>(Maheswaran and Elliott 2003)</td>
<td>UK</td>
<td>Living near main roads is associated with excess risk of mortality from stroke. Approximately 990 stroke deaths per year in the UK are attributable to road traffic pollution.</td>
</tr>
<tr>
<td>(Frumkin 2002)</td>
<td>Review</td>
<td>Sprawl (low residential density, low connectivity) is associated with less walking/bicycling, more automobile travel than denser communities</td>
</tr>
</tbody>
</table>