Geography matters to oral health and oral health inequalities

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Spatial turn in population health research

- using space (and time) to frame health research
- *where* matters in understanding how and why
- it matters *where* you live (and *when*)
- *where* also matters to ecological intervention

Geoffrey Rose, Professor of Epidemiology London School of Hygiene & Tropical Medicine

• Rose’s maxim:

“The causes of cases are not the causes of incidence.”

Environment Individual

‘Risk conditions’ POSITION the distribution of risk ‘Risk factors’ in the extreme of the risk distribution


Community A

Community B

Systolic blood pressure (mmHg):

120 130

140 150 hypertension

Body mass index (kg/m²):

22 25

30 35 obesity
Environment
Individual

‘Risk conditions’ SHAPE the distribution of risk
‘Risk factors’ in the extreme of the risk

Community A
Community B

BMI (kg/m$^2$) 15 | 18 | 22 | 25 → Overweight → 30 → Obesity

Macro-structure shapes meso-system shapes health vulnerabilities over time

Health inequities and differentials are shaped by social position

Spatialising processes sort the disadvantaged into areas defined by greater (worse) risk conditions

Deprivation amplification: inhibits capacity for psychological coping and positive health behaviour; induces adverse biological processes via activation of HPA and SAM axes
Explanatory model for population health: space and time


1. **Behaviour & Lifestyle “Risk Factors”**
2. **Psychosocial Factors**
3. **Social/Built Environment “Risk Conditions”**

**Clinical Risk Factors**

**Health & Disease**

(1) Health-related behaviour and lifestyle
(2) Positive/negative emotions and biological stress responses
(3) Direct biological stress responses to environmental cues

Reciprocal Determinism – Social Cognitive Theory

*Health is explained by the reciprocal impacts of cognitive, behavioural and environmental forces*
Spatial variability shapes variations in health trajectories over time.
Spatial variations in health exist *between* and *within* geographic areas, from states, to regions, communities and local neighbourhoods.
Georeference links survey or cohort participants to area-level exposures

1) Context
   Characteristics of places:
   • resources
   • opportunities,
   • living conditions

2) Composition
   Population characteristics
   • socio-demographic
   • socioeconomic
   • collective behaviour/norms
   • collective wellbeing

Context and composition are reciprocal in relation to each other

- Fruit and vegetable stores are *positively* related to area SES
- Fast-food outlets are *inversely* related to area SES

Montréal CMA
3.4 M residents
845 census tracts

**Expression:**

- Density
  - (number/surface area, Kernel)
  - (availability)
- Distance calculations
  - (accessibility)
- Proportions

Context and composition are reciprocal in relation to each other

Montréal CMA
3.4 M residents
845 census tracts
1,169 schools

Expressing context and composition: geographic information systems

**Physical Environment**
- Climate (e.g., rainfall, temperature)
- River systems, drainage, water
- Air quality, water, pollution

**Built environment**
- Land use / zoning / institutions
- Dwelling type / property values
- Public & private sector businesses
- Commercial and social services
- Transportation grid and modes
- Systematic social observation
- Road network, public transit
- Satellite images (NDVI)

**Social environment**
- Municipal complaints, requests
- Crime rates (violent, non-violent)
- Voter participation, election results
- Resident perceptions of local area
- Material/social deprivation index
- Education, employment, income
- Household structure, culture

**Geocoding**
- Residential location (georeference)
- Census areas, health administr. areas
- Spatial units – points, lines, polygons
- Network buffers, Euclidian buffers
- Typology & scale integration

**Health Data**
- Individual-level (cohort, registry)
- Biomedical/biochemical/clinical data
- Health behaviours, anthropometry
- Psychosocial, mental wellbeing
- Hospitalisations, outcomes

**EXPERTISE**
Physical Environment: Living within 200m of highway and adverse birth outcomes

NO\textsubscript{2} and PM\textsubscript{2.5} exposure

Singleton births
Île de Montréal
1.8 M residents
1997-2001

\( n = 99,819 \)

Adjusted for maternal education and area-level disadvantage (census tract % low income households)
**Built Environment:** Fast-food restaurant density and cardiovascular mortality

Montréal CMA
3.4 M residents
845 census tracts
1,178 fast-food outlets
30,388 cardiovascular deaths
1999-2003 (5 years)

RR=1.39 (1.19-1.63)
Per each 10% increase in fast-food outlet density (per km$^2$)

Adjusted for percentage residents married, female, immigrants, aged 15-24 full-time school, university degree, low-income households

**Social Environment: SGA birth and neighbourhood perceived security**

Île de Montréal
1.8 M residents

521 census tracts
49 police districts

Singleton births
*n = 99,819*

Adjusted for maternal age, education, marital status, birth place

SGA birth: below 10th percentile in birthweight for gestational age based on sex-specific Canadian foetal growth values

Referent: low perceived neighbourhood security

Statistical analysis (modelling) of spatial relationships
✓ Statistical analysis (modelling) of spatial relationships

→ Spatial analysis
Diabetes type 2 “hot spots”
Northwest Adelaide Health Study
Place and Metabolic Syndrome Project
Population oral health: what do we know?

Geo-spatial variation exists in oral health

Periodontitis prevalence varies spatially at state and county levels in the U.S. – highest for SE and SW states and for areas in the SE along the Mississippi Delta, as well as along the US and Mexico border. (Spatially descriptive only)


Composition (SES variation) is implicated in associations with oral health/OH inequality between populations (nations) (macro-structural)


Population oral health: what do we know?

Composition (SES variation) is implicated in associations with oral health and oral health inequality between and within local areas (meso-system)


*Very few longitudinal studies

*Contextual risk conditions not yet investigated
Health and local areas characterised by population composition (census SES)

Consistent and robust supporting evidence
Local area composition (census SES) varies with features of built environment

- Fast-food Outlets
- Greengrocers & Supermarkets
- Neighbourhood Walkability
- Public Parks & Green Space
- Recreational & Physical Activity Facilities & Resources
- Opportunities for Active Transportation
- Land Use & Street Networks
- Health & Medical Services
- Neighbourhood Aesthetics

Consistent and robust supporting evidence
Health and local areas characterised by built environments (not adj. for SES)

Census tract SES

- Fast-food Outlets
- Greengrocers & Supermarkets
- Neighbourhood Walkability
- Public Parks & Green Space
- Recreational & Physical Activity Facilities & Resources
- Opportunities for Active Transportation
- Land Use & Street Networks
- Health & Medical Services
- Neighbourhood Aesthetics

Physical Activity
Dietary Behaviour
Obesity/Overweight
Self-reported Health
Psychosocial Factors
Clinical Risk / Disease
Incident Risk / Disease
Health Care Utilisation
Disease Consequences

Evidence
- Consistent, robust
- Uneven, moderate
- Limited, mod-weak
Health and local areas characterised by built environments, adjusted for SES

Evidence

Uneven, moderate

Limited, mod-weak

Limited, mod-weak

Census tract SES

Fast-food Outlets
Greengrocers & Supermarkets
Neighbourhood Walkability
Public Parks & Green Space
Recreational & Physical Activity Facilities & Resources
Opportunities for Active Transportation
Land Use & Street Networks
Health & Medical Services
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Disease Consequences
Illustrative spatial agenda: Place and cardiometabolic risk project
– response to new SA Public Health Act

Research (NHMRC Project grant):
NWAHS – population-based biomedical cohort (n=4056): assess environmental attributes predicting incident CMR over time, test pathways/mechanisms

Knowledge translation (NHMRC Partnership grant):
✓ Engage stakeholders: Divisions of General Practice, municipal / state governments, local councils / urban planners, assess changeability of attributes
✓ Inform improved practices: clinics / health centres, and municipal / state policy to support healthful environments

Long-term aim:
Evaluate responses to practice-based and policy interventions
5-year analysis of NWAHS waves 1-2: context and incident CMR ($n=3,205$)

**Public Open Space**

- **Pre-diabetes/diabetes**
  - $RR_{per\ SD}: 0.76$
  - $95\%CI: 0.69, 0.84$
  - $p < 0.0001$

- **Hypertension**
  - $RR_{per\ SD}: 1.14$
  - $95\%CI: 1.07, 1.21$
  - $p < 0.0001$

- **Abdominal obesity**
  - $RR_{per\ SD}: 1.11$
  - $95\%CI: 1.03, 1.20$
  - $p < 0.008$

**Fast-food outlets**

**Retail Food Environment Index**


10-year analysis of NWAHS waves 1,2,3: context, composition and $\Delta$HbA$1_c$ – focus on mechanisms

- Cohort retention: wave 1 = 4,056; wave 2 = 3,564; wave 3 = 2,597
- N = 2,530 across W1-W3 restricting to urban area
- Spatial measures expressed for 1600 metre network buffers
- Accounting for spatial clustering within suburbs (n = 138), with individual-level covariates:
  - age, sex, educational attainment
- Full information maximum likelihood (FIML) to account for incomplete records (>12%) (observations MAR)
Context and composition: local descriptive norms

**Local descriptive norms**
- Separate population surveillance data (SAMSS)
- Concordance of 1600m buffer for cohort+SAMSS participants
- Buffer-specific prevalence rates:
  - **Overweight/obesity** ($\geq 25\text{kg/m}^2$)
  - Physical inactivity (<150 minutes/week)
  - Insufficient fruit intake (<2 serves/week)
Results: accounting for area-level SES (education)

- Food Environment
- Natural Environment
- Urban Form Environment

Context:
- Composition
- Area-Level Behav. Norms
- Area-level SES

Walkability:
- \( \Delta HbA1c \)
- \( p < 0.0001 \)
- \( -0.008 \ (-0.011, -0.005) \)

Overweight/obesity:
- \( p < 0.0001 \)
- \( 0.007 \ (0.004, 0.010) \)

N = 1,890

Standardised coefficients

Carroll S ... Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43
Effect modification by spatial norms of walkability-ΔHbA1c assoc.

- Local descriptive overweight/obesity norm x walkability
  Estimate (standardised): -0.004 (-0.007 to -0.001), p < 0.05

Carroll S ... Daniel M (2016). Local descriptive norms for overweight and physical activity, the built environment and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *Social Science & Medicine*; 166: 233-43
Results: accounting for area-level SES (education)

- Food Environment
- Natural Environment
- Urban Form Environment
- Area-Level Behav. Norms

\[ \Delta HbA_1c \]

\[ N = 1890 \]

Standardised coefficients

Participants centred 1600 metre network buffers

Context

Composition

Healthful-food availability

NS

\[ \text{Overweight/obesity} \]

\[ p < 0.0001 \]

\[ 0.008 (0.005-0.011) \]

Carroll S ... Daniel M (2017). Local descriptive bodyweight and dietary norms, food availability and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *BMC Public Health*; 17(149): 1-14
Effect modification by spatial norms of food availability-$\Delta$HbA$_{1c}$

- Local descriptive overweight/obesity norm x healthful food availability
  Estimate (standardised): -0.006 (-0.009 to -0.002), $p < 0.01$

$N = 1,890$

Carroll S ... Daniel M (2017). Local descriptive bodyweight and dietary norms, food availability and 10-year change in glycosylated haemoglobin in an Australian biomedical cohort. *BMC Public Health*; 17(149): 1-14
Mediation by healthful *versus* unhealthful behaviour of association between area-level collective norms and ΔHbA1c across 10 years

**Path c**
- Local descriptive overweight/obesity norm (standardised)
  - β = 0.006 (95%CI 0.002 to 0.010), p = 0.006

**Path a**
- Low-level physical activity (PA)
  - β = 0.015 (95%CI -0.009 to 0.039), p = 0.219
- Recommended level of physical activity (PA)
  - β = -0.059 (95%CI -0.086 to -0.032), p < 0.001

**Path b**
- Low-level physical activity (PA)
  - β = -0.011 (95%CI -0.021 to -0.001), p = 0.028
- Recommended level of physical activity (PA)
  - β = -0.015 (95%CI -0.023 to -0.006), p = 0.001

**Indirect effects (path a x path b):**
- Through low PA (x100) \(\beta = -0.016 (-0.048 to 0.016), p = 0.313\) ns
- Through recommended PA (x100) \(\beta = 0.085 (0.019 to 0.151), p = 0.011\)
- Total indirect effects (x100) \(\beta = 0.069 (0.013 to 0.125), p = 0.016\)

\(n=1,907\)

Models adjusted for individual-level covariates and area-level median household income

PA = physical activity; reference category is sedentary (i.e., no physical activity)

Note on scale:

**ABS SEIFA Index according to spatial scales**

ABS confidentiality prohibits unit record census data being made available

**Collection District** (pre 2011) or **SA1** (2011 onward) is *smallest* unit

ABS = Australian Bureau of Statistics  
SEIFA = Socio-Economic Indexes for Areas
Note on scale:

ABS SEIFA Index according to spatial scales

State Suburb

Masking of CD heterogeneity
Note on scale:

**ABS SEIFA Index according to spatial scales**

**Postal Area**

Masking of SSC heterogeneity
Note on scale:

ABS SEIFA Index according to spatial scales

Statistical Local Area

Masking of POA heterogeneity
Note on scale:

**ABS SEIFA Index according to spatial scales**

**Local Government Area**

Masking of SLA heterogeneity
### Score

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<thead>
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<th>Spatial Unit</th>
<th>Low SEIFA House</th>
<th>HIGH SEIFA House</th>
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<tbody>
<tr>
<td>CCD</td>
<td>826.42</td>
<td>1059.35</td>
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<tr>
<td>SSC</td>
<td>891.45</td>
<td>1025.43</td>
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<td>POA</td>
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<td>SLA</td>
<td>889.32</td>
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<tr>
<td>LGA</td>
<td>922.53</td>
<td>922.53</td>
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<tr>
<td>Change</td>
<td>96.11</td>
<td>-136.82</td>
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### Decile

<table>
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<tr>
<th>Spatial Unit</th>
<th>Low SEIFA House</th>
<th>HIGH SEIFA House</th>
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<tbody>
<tr>
<td>CCD</td>
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<td>5</td>
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<tr>
<td>Change</td>
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Spatial oral health/ oral health inequalities agenda
Starting point: clinical lens, individual focus

BUT effective prevention obliges a continuum approach extending to the population level

“Environment and policy changes are the most promising strategies for controlling obesity and improving diet and physical activity”

- U.S. Institute of Medicine, 2008
Framing oral health inequalities for prevention: *community shapes individuals*

Influences other than individual risk factors …

Impact of broader community features:

- population norms
- community resources
- adverse living conditions
- social and built environments
- human interconnections

Framing oral health inequalities for prevention: *region shapes communities*

Across regions, communities are different; they vary in the features of their populations.

Across regions, communities also differ in the features of their environmental contexts.

Framing oral health inequalities for prevention: *Levels of the exposure spectrum*

Recommendations to inform oral health and social policy, health services planning and delivery

Research: Theory-driven conceptualisation and operationalisation (frameworks, relationships, constructs)

Use of GIS and spatial statistics with multi-level models

Partnerships with government, public health, clinicians, industry:
Integration into public health surveillance systems of GIS-based exposures (conditions and outcomes) to geo-reference specific spatial relationships
Ecological initiatives (multi-level, multi-sector) for defined spatial settings, to effect and evaluate actions to change local-area meso-system conditions
GIS-based comparative and evaluative research on different policy environments and policy changes to improve macro-level conditions
Thank you