GeoHealth
The Importance of Place in Understanding Health

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Health Research Institute
University of Canberra
The Art, Science and Business of Geospatial GeoHealth
Tobler’s Law

Everything is related to everything else, but near things are more related than distant things.

-Waldo Tobler

“All Pervasive Enabler”

• All: DATA

• Pervasive: ALL disciplines

• Enabler: GIS
Early GeoHealth Work

Not John Snow!
Charles Booth
Charles Booth’s London poverty maps
The Streets are coloured according to the general condition of the inhabitants, as under:

- **Lowest class. Vicious, semi-criminal.**
- **Very poor, casual. Chronic want.**
- **Poor. 18s. to 21s. a week for a moderate family.**
- **Mixed. Some comfortable, others poor.**
- **Fairly comfortable. Good ordinary earnings.**
- **Middle-class. Well-to-do.**
- **Upper-middle and Upper classes. Wealthy.**

A combination of colours— as dark blue and black, or pink and red—indicates that the street contains a fair proportion of each of the classes represented by the respective colours.
Evolving Interest
Well established link between social disadvantage and poorer health outcomes
Socio-economic Status

• SES strong relationship with health outcomes.
• Includes:
  – Obesity
  – Diabetes
  – Cardiovascular Disease
  – Cancer
  – Mental Illness
  – Hypertension
  – High Cholesterol
  – Metabolic Syndrome
Importance of “Place” to health

• Associations
  – Obesity
  – Diabetes
  – Cardio vascular Disease
  – Cancer
  – Mental Illness
  – Hypertension
  – High Cholesterol
  – Metabolic Syndrome
New map shows undiagnosed dementia cases in UK

A study of dementia diagnosis in the UK predicted by the Alzheimer’s Society and Alzheimer’s Research UK estimated that more than a million people will suffer from dementia by 2033 in the UK. The research also says data figures show that half a million people were not living without it diagonally.

Vaccine-preventable disease outbreaks

Browse our interactive map to track outbreaks of vaccine-preventable diseases around the world.

The map uses information published by the World Health Organization and the Centers for Disease Control and Prevention. This interactive tool is widely accepted by the global health community for its role in raising awareness of the continued prevalence of easily preventable diseases.
SES and Place

- Associations are common
- Spatial SES
- Create a measure at the property level that could provide a disaggregated SES indicator
- Application in Adelaide used GIS, Sales and Property Cadastre data “Relative Location Factor (RLF)”
- For more detail regarding the Methodology see:
Methodology

• Georeferenced sales data for May to October to avoid changes to sales market
• The RLF was calculated using the hedonic global Ordinary Least Squares (OLS) regression model comprising independent variables that were deliberately ‘blind’ to location
• The residual was then considered to represent these omitted location variables at each sale point
• These are then interpolated across the study area to give a continuous RLF surface from which values can be extracted for each property
Continuous RLF

Blue areas are below the mean

Red areas are above the mean

- RLF Values are extracted to dwelling point data
• ABS* calculate several Indices
• ABS confidentiality prohibits unit record census data being made available
• ABS provide SEIFA for spatial units
  – Collection District (pre 2011) or SA1 smallest unit
  – Also (pre 2011) Suburb, Postal Area, SLA, LGA and 2011 the SA1-SA4
• Remember MAUP & Ecological Fallacy
• Lets look at some of these spatial units in Adelaide

* Australian Bureau of Statistics
### Score

<table>
<thead>
<tr>
<th>Spatial Unit</th>
<th>Low SEIFA House</th>
<th>High SEIFA House</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCD</td>
<td>826.42</td>
<td>1059.35</td>
</tr>
<tr>
<td>SSC</td>
<td>891.45</td>
<td>1025.43</td>
</tr>
<tr>
<td>POA</td>
<td>891.45</td>
<td>939.69</td>
</tr>
<tr>
<td>SLA</td>
<td>889.32</td>
<td>938.27</td>
</tr>
<tr>
<td>LGA</td>
<td>922.53</td>
<td>922.53</td>
</tr>
<tr>
<td>Change</td>
<td>96.11</td>
<td>-136.82</td>
</tr>
</tbody>
</table>

### Decile

<table>
<thead>
<tr>
<th>Spatial Unit</th>
<th>Low SEIFA House</th>
<th>High SEIFA House</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCD</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>SSC</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>POA</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>SLA</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>LGA</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Change</td>
<td>4</td>
<td>-5</td>
</tr>
</tbody>
</table>

### Change to Score

![Change to Score Graph](image-url)

### Change to Decile

![Change to Decile Graph](image-url)
RLF: Within CD variation

- Spatial variation within the RED CD noted through the change in decile of the individual property scores
- More aligned with neighbouring CDs which may suggest CD boundaries are inappropriate SES boundaries
Utility of General Practice Data Capture and Spatial Analysis for Understanding COPD and Asthma

Prevalence and standardised incidence ratios of COPD by medical practice

<table>
<thead>
<tr>
<th>Practice</th>
<th>Active patients</th>
<th>Observed cases</th>
<th>Expected cases</th>
<th>Prevalence (=O/A*100%)</th>
<th>SIR (=O/E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice 1</td>
<td>12,032</td>
<td>374</td>
<td>409</td>
<td>3.1</td>
<td>0.91</td>
</tr>
<tr>
<td>Practice 2</td>
<td>8,004</td>
<td>345</td>
<td>290</td>
<td>4.3</td>
<td>1.19</td>
</tr>
<tr>
<td>Practice 3</td>
<td>7,085</td>
<td>243</td>
<td>269</td>
<td>3.4</td>
<td>0.90</td>
</tr>
<tr>
<td>Practice 4</td>
<td>4,140</td>
<td>103</td>
<td>154</td>
<td>2.5</td>
<td>0.67</td>
</tr>
<tr>
<td>Practice 5</td>
<td>2,464</td>
<td>65</td>
<td>77</td>
<td>2.6</td>
<td>0.84</td>
</tr>
<tr>
<td>Total</td>
<td>33,725</td>
<td>1,130</td>
<td>1,228</td>
<td>3.4</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Multilevel logistic regression of active COPD

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Model 1</th>
<th></th>
<th></th>
<th>Model 2</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Est.</td>
<td>SE</td>
<td>p</td>
<td></td>
<td>Est.</td>
<td>SE</td>
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<tr>
<td>Within-cluster</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>2.348</td>
<td>0.239</td>
</tr>
<tr>
<td>Age²</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.697</td>
<td>1.121</td>
</tr>
<tr>
<td>Male</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.522</td>
<td>0.077</td>
</tr>
<tr>
<td>Female</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.0</td>
<td>---</td>
</tr>
<tr>
<td>Smoker</td>
<td>---</td>
<td>---</td>
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<td>---</td>
<td>2.477</td>
<td>0.116</td>
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<tr>
<td>Ex-smoker</td>
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<td>---</td>
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<td>---</td>
<td>1.522</td>
<td>0.093</td>
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<tr>
<td>Never smoked</td>
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<td>---</td>
<td>0.0</td>
<td>---</td>
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<tr>
<td>Indigenous Australian</td>
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<td>---</td>
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<td>---</td>
<td>0.871</td>
<td>0.341</td>
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<tr>
<td>Non-Indigenous Australian</td>
<td></td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.0</td>
<td>---</td>
</tr>
<tr>
<td>Unmarried</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.365</td>
<td>0.126</td>
</tr>
<tr>
<td>Married</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.0</td>
<td>---</td>
</tr>
<tr>
<td>N-Comorbidities</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1.060</td>
<td>0.029</td>
</tr>
<tr>
<td>Between-cluster</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRSD (Q4)</td>
<td>-1.280</td>
<td>0.171</td>
<td>&lt;0.0001</td>
<td>[-1.614 -0.945]</td>
<td>-0.513</td>
<td>0.182</td>
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<tr>
<td>IRSD (Q3)</td>
<td>-0.712</td>
<td>0.114</td>
<td>&lt;0.0001</td>
<td>[-0.936 -0.489]</td>
<td>-0.299</td>
<td>0.117</td>
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<tr>
<td>IRSD (Q2)</td>
<td>-0.358</td>
<td>0.083</td>
<td>&lt;0.0001</td>
<td>[-0.520 -0.196]</td>
<td>-0.156</td>
<td>0.091</td>
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<tr>
<td>IRSD (Q1)</td>
<td>0.0</td>
<td>---</td>
<td></td>
<td></td>
<td>0.0</td>
<td>---</td>
</tr>
</tbody>
</table>
The North West Adelaide Health Study (NWAHS)

- longitudinal population-based biomedical cohort
- three waves of data collected between 2000 and 2010.
- self-report socio-demographic and health data.
- clinic biomedical data and prescription medication.
- residential address used to geocode.
- ethics approval form the Human Research Ethics Committees of:
  - the University of South Australia;
  - the North West Adelaide Health Service: and
  - the South Australian Department of Health.
### NWAHS Analysis

<table>
<thead>
<tr>
<th>Natural breaks</th>
<th>RR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central Obesity</strong>*</td>
<td></td>
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<tr>
<td>RLF: 3 v 1</td>
<td>0.89</td>
<td>0.83</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>0.0004</td>
<td></td>
<td></td>
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<tr>
<td>RLF: 2 v 1</td>
<td>0.93</td>
<td>0.89</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>0.0033</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypertriglyceridemia</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.79</td>
<td>0.70</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>0.0005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 2 v 1</td>
<td>0.90</td>
<td>0.82</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>0.0173</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reduced HDL#</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.79</td>
<td>0.67</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>0.0025</td>
<td></td>
<td></td>
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<tr>
<td>RLF: 2 v 1</td>
<td>0.87</td>
<td>0.78</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>0.0159</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypertension</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.94</td>
<td>0.88</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>0.0824</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 2 v 1</td>
<td>0.90</td>
<td>0.85</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diabetic\diabetes Risk</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.52</td>
<td>0.43</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 2 v 1</td>
<td>0.79</td>
<td>0.70</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High LDL^</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.95</td>
<td>0.77</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>0.6277</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 2 v 1</td>
<td>1.05</td>
<td>0.90</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>0.5399</td>
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<td></td>
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<tr>
<td><strong>CMR Score</strong>*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 3 v 1</td>
<td>0.81</td>
<td>0.76</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLF: 2 v 1</td>
<td>0.91</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Wave 1 NWAHS, 2001, n=3585
- Factors - Log binomial generalized linear models
- CMR score - Poisson regression
- Parameter estimates exponentiated - relative risk (RR)
- Accounted for age, gender and education (no university degree)
- Statistical significance was set at alpha = 0.05
- Statistically significant relationship between RLF & CMR score all but one of the risk factors.
- Participants in the advantaged and intermediate group had a lower risk for CMD.
- CMR score RR for the most advantaged was 19% lower (RR = 0.81; CI 0.76-0.86; p <0.0001) and the middle group was 9% lower (RR = 0.91; CI 0.86-0.95; p <0.0001) than the least advantaged group.

Gender, Age and Bachelor Education were included in all models.
*** Gender, Age and Bachelor Education Significant.
# Gender Significant.
^ Age Significant.

Is walkability associated with a lower cardiometabolic risk?
Neil T. Coffee a,b, Natasha Howard a, Catherine Paguet a,c, Graeme Hugo b, Mark Daniel a,d

Table 3
Parameter estimates for associations between cardiometabolic risk score and spatial unit walkability score (n = 3593) a.

<table>
<thead>
<tr>
<th>Walkability score</th>
<th>RR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 m road buffer</td>
<td>0.97</td>
<td>0.94</td>
<td>1.00</td>
</tr>
<tr>
<td>1000 m road buffer</td>
<td>0.94</td>
<td>0.91</td>
<td>0.98</td>
</tr>
<tr>
<td>1600 m road buffer</td>
<td>0.94</td>
<td>0.90</td>
<td>0.97</td>
</tr>
<tr>
<td>Collection district</td>
<td>0.98</td>
<td>0.94</td>
<td>1.03</td>
</tr>
<tr>
<td>derived suburb</td>
<td>0.97</td>
<td>0.91</td>
<td>1.04</td>
</tr>
</tbody>
</table>

 a Adjusted for individual gender, age (<55 or ≥55), education (no university or university degree), weekly income (0–19,999; 20,000–59,999, >60,000) and suburb weekly median household income.

Lower CMR score was associated with higher WI for the three road buffer representations of the built environment with a three per cent reduction in relative risk for the 500 m road buffer, and six per cent for the 1000 m and 1600 m road buffers. No statistical relationship was found for either of the two predetermined administrative spatial unit. These results indicate that the choice of spatial unit used and its scale influence the nature of relationships estimated between the built environment and clinical risk factors.
Location Data

- Dwelling density
- Destination choice
- Road system
  - connectivity/accessibility/barriers
  - Main road exposure/traffic/noise
- Open space/Greenspace/Parks/Sport and recreation
- Crime and Safety
- Food environment
  - Unhealthy
  - Healthy
- Topography
- Service and facility locations
Health Data

• Hard health outcomes difficult to access at a spatial scale that is meaningful
• Confidentiality problems
• We have the technology but generally lack the access to data
• Data available for administrative units that are not meaningful!
• MAUP issues
Measures

- Counts
- Distance
- Density
- Access
- Index
- Ratio
Data Issues

• Confidentiality
• Data linkage costs
• Large spatial units that mask spatial variation
• Poor quality data especially address data
• Enormous cost and time to geocode health data
• Apart from these issues – it is very difficult to get data for research
Acute Cardiac ARIA Index

Based on hospital categories and travel time to hospital by road via ambulance (dispatch + travel to site + on-site + travel to hosp)

* Exception
Class 7 - no ambulance nearby, but <= 30 minutes to cat5 hospital or remote clinic directly by car

Urban/Other @ 40/80kph

1. Cat1 <= 1 hour
2. Cat2 <= 1 hour
3. Cat3 <= 1 hour
4. Cat4 <= 1 hour
5. Cat5 <= 1 hour
6. Nearest 1-3 hours
7. Cat5 <= 30 mins
8. Nearest > 3 hours

Desert

Data sources:
Australia - Australian Bureau of Statistics
Deserts - Bureau of Meteorology, Climate Zones
Ambulance Stations - Individual State Ambulance Services
Roads - Primeway Sewer Business Insight / Tonkin Consulting, StreetFire
Remote Clinics - Individual State Health Departments, NACCHO State Affiliates
Hospitals - Dept. of Health and Ageing, Australian Institute of Health and Welfare

Final Report 2010
www.unisa.edu.au/cardiaria
Example: Geocoding

N=572,496

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual XY</td>
<td>453674</td>
<td>(79.2%) Exact match found (or almost exact where unit/flat/appt number wasn’t found)</td>
</tr>
<tr>
<td>SA2</td>
<td>7009</td>
<td>(1.2%)</td>
</tr>
<tr>
<td>Review</td>
<td>8963</td>
<td>(1.6%) Manual clerical review needed to classify as XY, SA1, SA2 or reject</td>
</tr>
<tr>
<td>Unclassified</td>
<td>102009</td>
<td>(17.8%) Not enough information to be geocoded at XY/SA1 level; SA2 codes could be generated where locality and postcode were known; some could still be worth cleaning for future geocoding</td>
</tr>
<tr>
<td>Reject</td>
<td>841</td>
<td>(0.1%) No match possible</td>
</tr>
</tbody>
</table>
New Projects

• Signing a $2.7m collaboration with the Dasman Diabetes Institute to build Geohealth infrastructure, capability and conduct research
• Developing a MOU with ESRI to build a GeoHealth Hub at University of Canberra
• Starting a Graduate Certificate in GeoSpatial Health Semester 2 at UC
• Delivery of Graduate Certificate in GeoSpatial Health in Kuwait starting October 2018
Spatial Epidemiology and Evaluation Research Group

Geo-Health Lab

Physical Environment
- Climate (e.g., Rainfall, Temperature)
- River systems, drainage
- Topography
- DEM

Built environment
- Land use / zoning
- Dwelling type
- Road network
- Satellite images (NDVI)
- Public/private sector businesses
- Transport grid and modes
- Food sources
- Open space
- Infrastructure,
- Service environment

Social
- Census
- Income
- Education
- Crime rates
- Unemployment
- Poverty
- Collective hopelessness
- Social networks

Geocoding
- Residential location
- Census Geographic Areas

Health Data

Geo-
Health Lab
Short Report

Food environment, walkability, and public open spaces are associated with incident development of cardio-metabolic risk factors in a biomedical cohort.

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3School of Medical Sciences, Flinders University, Bedford Park, SA, 5042, Australia

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Is walkability associated with a lower cardio-metabolic risk?

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3School of Medical Sciences, Flinders University, Bedford Park, SA, 5042, Australia

Submitted 12 July 2015; Revised in revised form 3 January 2016; Accepted 4 January 2016; First published online 14 June 2016

Validating and measuring public open space is not a walk in the park

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Does Physical Activity Mediate the Associations between Local-Area Descriptive Norms, Built Environment Walkability, and Glycosylated Hemoglobin?

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Local descriptive body weight and dietary norms, food availability, and 10-year change in glycosylated haemoglobin in an Australian population-based biomedical cohort

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Local descriptive norms for overweight/obesity and physical inactivity, features of the built environment, and 10-year change in glycosylated haemoglobin in an Australian population-based biomedical cohort

Suzanne J. Carroll 1, 2, Catherine Paquet 3, 4, Natalia J. Howard 5, Neil T. Coffee 6, Anne W. Taylor 7, Theo Niyonsenga 8, Mark Daniel 9, 10

Contributions of local-area fast-food availability and area-based weight and dietary norms to 10-year change in cardiometabolic risk

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Neighbourhood Environmental Attributes Associated with Walking in South Australian Adults: Differences between Urban and Rural Areas

Narelle M. Berry 1, 2, Neil T. Coffee 3, Rebecca Nolan 4, James Dollman 5 and Takemi Sugiyama 6

Visualising 30 Years of Population Density Change in Australia’s Major Capital Cities

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Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes

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Are accessibility and characteristics of public open spaces associated with a better cardiometabolic health?

Catherine Paquet 1, 7, 8, Thomas P. Orschulik 1, 7, Neil T. Coffee 3, Natalia J. Howard 5, Graeme Hugo 1, 2, Anne W. Taylor 7, Robert J. Adams 3, Mark Daniel 9, 10

Application of Geographic Modeling Techniques to Quantify Spatial Access to Health Services Before and After an Active Cardiac Event: The Carolina ARIA Project

Robyn A. Clark 1, Neil Coffee 3, Dorothy Turner 2, Katrina A. Gibson 2, Deborah Yen 1, Conlin 2, David Wilkinson 2, John Stewart 1 and Andrew M. Timmins
Conclusions

• We can do great things (with access to data!!!)
• Partner with health agencies to gain confidence
• We do not do this to embarrass anyone, but to improve population health
• Spatial industry has data providers, software and applied (users)
• I am not a young professional – but still believe in “not giving up” (especially around data access!!!)
Thank You

Questions
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