Association between the urban environment and chronic disease to identify communities at risk

CURRENT STATUS: UNDER REVIEW

Ken Wei Tan
National University of Singapore

e0145748@u.nus.edu Corresponding Author
ORCiD: https://orcid.org/0000-0003-3224-4619

Qianyu Yang
National University of Singapore

Yin Ai Lean
National University of Singapore

Joel Ruihan Koo
National University of Singapore

Alex R Cook
National University of Singapore

Borame L Dickens
National University of Singapore

DOI: 10.21203/rs.2.18164/v1

SUBJECT AREAS
Geographic Information Systems

KEYWORDS
Statistical modelling, chronic disease, spatial epidemiology, urbanisation, environmental health
Abstract

Background: With increasing urbanisation rates, assessments must be made on the impact of the built environment on the health of populations. As the bulk of healthcare expenditure in developed countries is borne by the elderly through chronic disease management and treatment costs, intervening using the built environment can have lasting population-wide effects.

Methods: Using two cohort studies for training and validation, we quantified each individual’s local context based on their residential address and derived geographical exposures adapted from the International Physical Activity and the Environment Network guidelines. Bayesian inference was used to develop a regression model that examines the impacts of the geographical exposures and predicts mean body mass index and prevalence of type 2 diabetes mellitus, acute myocardial infarction and stroke by communities.

Results: The distance to the nearest retail outlet was found to be negatively associated with body mass index. Our prediction model shows good accuracy (AUC > 0.75) for predicting type 2 diabetes mellitus, acute myocardial infarction and stroke. National-level maps were generated that predict the health of communities by mean body mass index and overall chronic disease risk.

Conclusions: The predictive model has the ability to predict on a macro scale the overall health of a community. Understanding the geospatial distribution of chronic disease risk allows for evidence-based policymaking with urban-specific interventions that improve overall population health.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed.

However, the manuscript can be downloaded and accessed as a PDF.

Tables

Table 1 Summary statistics of the MEC and CHS. Reported numbers are means, with brackets indicating the 5th and 95th percentile of the data.
### Demographic variables

| Variable                  | MEC (n = 10499) | CHS (n = 5275) |
|---------------------------|-----------------|----------------|
| Age                       | 46 (22,72)      | 55 (30,79)     |
| Male                      | 43%             | 41%            |
| Ethnicity                 |                 |                |
| Chinese                   | 46%             | 74%            |
| Malay                     | 26%             | 13%            |
| Indian                    | 28%             | 11%            |
| Other                     | <1%             | 2%             |
| Smoking status            |                 |                |
| Non-smoker                | 76%             | 79%            |
| Ex-smoker                 | 8%              | 9%             |
| Current smoker            | 16%             | 12%            |
| House price in millions, S$| 0.63 (0.22,2.77)| 0.43 (0.22,0.8)|

### Geographical variables

| Variable                          | MEC                         | CHS                         |
|-----------------------------------|-----------------------------|------------------------------|
| Residential area in km²           | 0.43 (0.23,0.57)            | 0.44 (0.25,0.57)             |
| Retail area in km²                | 0.04 (0.00,0.13)            | 0.02 (0.00,0.05)             |
| Civic/institutional area in km²   | 0.07 (0.01,0.17)            | 0.07 (0.01,0.15)             |
| Private recreation area in km²    | 0.01 (0.00,0.06)            | 0.02 (0.00,0.11)             |
| Park area in km²                  | 0.03 (0.00,0.19)            | 0.05 (0.00,0.24)             |
| Distance to nearest retail in km  | 0.16 (0.00,0.55)            | 0.20 (0.00,0.52)             |
| Distance to nearest civic/institutional in km | 0.12 (0.02,0.31) | 0.11 (0.03,0.24) |
| Distance to nearest private recreation in km | 0.82 (0.10,2.07) | 0.45 (0.15,1.02) |
| Distance to nearest park in km    | 0.30 (0.03,0.82)            | 0.19 (0.03,0.58)             |
| Distance to nearest public transport in km | 0.12 (0.03,0.27) | 0.11 (0.03,0.23) |
| Distance to nearest food establishment in km | 0.13 (0.00,0.30) | 0.17 (0.01,0.46) |

### Health outcomes

| Variable    | MEC         | CHS          |
|-------------|-------------|--------------|
| BMI         | 24.8 (17.3,36.4) | 24.7 (17.7,34.9) |
| DM          | 10%         | 12%          |
| AMI         | 2%          | 4%           |
| Stroke      | 1%          | 1%           |

Table 2 Unstandardised effect sizes and odds ratios for the full Bayesian hierarchical model for BMI and chronic disease risk. Significant effects are in bold.
| Location/Variable                                    | Effect size (CI)      | Odds ratio (CI)       |
|----------------------------------------------------|-----------------------|-----------------------|
| Residential area in km
²                              | -0.45 (-1.62, 0.51)   | 1.22 (0.59, 2.42)     |
| Retail area in km
²                                | -1.35 (-4.00, 1.28)   | 0.32 (0.05, 2.06)     |
| Civic/institutional area in km
²                | -1.19 (-3.69, 1.31)   | 0.81 (0.13, 4.42)     |
| Private recreation area in km
²                | 4.79 (-0.72, 10.20)   | 0.24 (0.00, 12.2)     |
| Park area in km
²                                 | 0.88 (-1.06, 2.84)    | 0.82 (0.21, 3.13)     |
| Distance to nearest retail in km                 | -0.95 (-1.71, -0.23)  | 0.63 (0.35, 1.12)     |
| Distance to nearest civic/institutional in km   | -0.70 (-1.95, 0.55)   | 0.89 (0.35, 2.20)     |
| Distance to nearest private recreation in km    | 0.09 (-0.12, 0.31)    | 0.97 (0.84, 1.14)     |
| Distance to nearest park in km                   | 0.02 (-0.41, 0.47)    | 1.18 (0.85, 1.64)     |
| Distance to nearest public transport in km      | -1.36 (-2.82, 0.01)   | 2.65 (0.92, 7.28)     |
| Distance to nearest food establishment in km    | 0.71 (-0.67, 2.06)    | 2.24 (0.83, 6.10)     |

Demographic Variables

| Demographic Variable                        | Effect size (CI)      | Odds ratio (CI)       |
|---------------------------------------------|-----------------------|-----------------------|
| Age                                         | 0.02 (0.02, 0.03)     | 1.09 (1.09, 1.10)     |
| House price in $100,000                      | -1.97 (-3.26, -0.69)  | 0.31 (0.11, 0.85)     |
| BMI                                         | NA                    | 1.07 (1.06, 1.08)     |
| Female                                      | 0.25 (0.05, 0.45)     | 0.68 (0.59, 0.79)     |
| Malay                                       | 3.56 (3.33, 3.79)     | 1.43 (1.20, 1.70)     |
| Indian                                      | 3.10 (2.89, 3.32)     | 2.94 (2.53, 3.42)     |
| Other                                       | 3.02 (1.64, 4.43)     | 1.13 (0.40, 2.76)     |
|                | Ex-Smoker       | Smoker         |
|----------------|-----------------|----------------|
|                | 0.32 (-0.03, 0.66) | 1.41 (1.14, 1.74) |
|                | -0.68 (-0.95, -0.41) | 0.96 (0.77, 1.17) |

Figures

Figure 1

ROC curves of the Multi-Ethnic Cohort (training) and the Community Health Study (validation) for DM, AMI and stroke.
Maps of the 17 minizones in Bukit Panjang and Queenstown with more than 10 residents and Hosmer-Lemeshow plots of mean BMI, DM, AMI and stroke prevalence. Confidence intervals are Agresti-Coull confidence intervals. Colours of the minizones on the maps correspond to the colours of the respective points in the Hosmer-Lemeshow plots. Some confidence intervals have been truncated.
Figure 3

National-level maps of mean BMI, relative risk of chronic disease, demography-adjusted mean BMI and demography-adjusted chronic disease risk. Red areas have worse health outcomes and green areas have better health outcomes. Areas with less than 100 residents were excluded and are coloured white.