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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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ABSTRACT

We investigated whether residential environment characteristics related to food (unhealthful/healthful food sources ratio), walkability and public open spaces (POS; number, median size, greenness and type) were associated with incidence of four cardio-metabolic risk factors (pre-diabetes/diabetes, hypertension, dyslipidaemia, abdominal obesity) in a biomedical cohort ($n=3205$). Results revealed that the risk of developing pre-diabetes/diabetes was lower for participants in areas with larger POS and greater walkability. Incident abdominal obesity was positively associated with the unhealthful food environment index. No associations were found with hypertension or dyslipidaemia. Results provide new evidence for specific, prospective associations between the built environment and cardio-metabolic risk factors.



## 1. Introduction

A number of studies have now reported on the associations between built environmental attributes, such as urban form and access to healthful food and physical activity resources, and risk factors for cardio-metabolic diseases (Leal and Chaix, 2011; Feng et al., 2010). This body of research has been criticised on the basis of substantial heterogeneity across studies in the way built environmental features are operationalised, focusing on a single environmental attribute in isolation from other potentially correlated features, and the lack of longitudinal evidence (Leal and Chaix, 2011; Feng et al., 2010; Daniel et al., 2008). In addition, the majority of studies have focused on body mass index (BMI) or obesity as a sole marker of cardio-metabolic risk (Leal and Chaix, 2011). Although cardio-metabolic risk factors such as (central) obesity, impaired glycaemia, hypertension and dyslipidaemia tend to cluster and collectively define the metabolic syndrome, they represent distinct risk components under the control of convergent but distinct biological pathways and vary in their ability to predict the onset of type 2 diabetes and cardiovascular diseases (Sattar et al., 2008). These risk components also respond differentially to behavioural interventions, most likely reflecting behavioural specificity of biological conditioning, such as that demonstrated for physical activity (Boulé et al., 2001). It is therefore possible that these distinct risk components are differentially influenced by specific built environmental features that would theoretically promote either physical activity or healthful eating. The aim of the present study was to test this hypothesis by

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investigating whether residential built environment attributes related to food, public open space (POS), and walkability differed in their capacity to predict incident development of a range of cardio-metabolic risk factors.

## 2. Methods

This study is part of the Place and Metabolic Syndrome project which investigates associations between built environment attributes and cardio-metabolic risk factors. The study draws on the first two waves of data collection of the North West Adelaide Health Study (NWAHS), a longitudinal biomedical cohort with three waves of data collected over ten years. Adults aged 18 years and over from the northern and western metropolitan regions of Adelaide, South Australia, were randomly selected at baseline from the Electronic White Pages telephone directory. Behavioural, psychosocial, and socio-demographic information were collected using self-reported telephone and paper-based questionnaire. Anthropometric and blood pressure measurements as well as fasting blood samples were obtained during clinic visits. A total of 4056 participants provided clinical data at baseline in 2000–2003 (response rate=49.4%; Grant et al., 2006); 3205 underwent follow up in 2005–2006 (233 not contacted, 100 died, 22 unable to complete, 138 refused, 358 refused clinical assessment). The socio-demographic profile of the NWAHS is comparable to the metropolitan region of Adelaide with respect to education and income, with 11.3% of participants having a bachelor's degree and 69.4% of households reporting earnings of over 20,000 AUD each year. Participants were assigned a geo-reference for their residential address. Ethics approval was obtained from Human Research Ethics Committees from the University of South Australia, Central Northern Adelaide Health Service and South Australian Department for Health and Ageing.

### 2.1. Measures

Change in cardio-metabolic risk was expressed as the incidence of four cardio-metabolic risk factors selected to reflect components of the Metabolic Syndrome. These included: pre-diabetes/diabetes ($HbA_{1c}$ $\geq$5.7% or fasting plasma glucose $\geq$5.6 mmol/L or diagnosed diabetes); hypertension (diastolic/systolic BP $\geq$85/130 mmHg or treatment for hypertension); dyslipidaemia (triglycerides $\geq$1.7 mmol/L or high-density lipoprotein (HDL) $<$1.03 (males)/$<$1.29(females), or treatment with lipid-modifying medication); and abdominal obesity ($\geq$94 cm(males)/$\geq$80 cm (females)).

All environmental attributes were defined at baseline. Road-network distance from participants' residence to selected resources was calculated within the Network Spatial Analyst extension of ArcGIS (version 9.3.1, ESRI, Redlands, California). Only resources located within a 1000 m ($\sim$10–15 min walk) were considered.

The relative 'unhealthfulness' of the food environment was captured using a Relative Food Environment Index (RFEI (California Centre for Public Health Advocacy, 2008)) representing the ratio of fast-food restaurants and unhealthful food stores to healthful food stores. Locations of food outlets were obtained from the 1999 South Australian Retail Database (Planning SA, South Australian Government). Food outlets were coded as either healthful (e.g. greengrocers, butchers, supermarkets ($>$200 $m^2$ of floor space), more healthful take-away options (e.g. sushi), and health food shops) or unhealthful (e.g. fast-food outlets (chain and non-chain), bakeries, sweet food retailers and convenience stores).

Walkability was measured using an index constructed from dwelling density, intersection density (all intersections with three or more directions of travel), land use entropy (three land use groups, residential, commercial and recreation), and retail footprint (ratio of gross retail floor space to total parcel area, wherein low ratios indicate large car parks and pedestrian unfriendly environment). The four walkability components were categorised into deciles and summed. A detailed description has already been published (Coffee et al., 2013).

POS characteristics were expressed as the number, median size, greenness (Normalised Difference Vegetation Index (NDVI)) and type (percentage associated with organised sport) of available POS as described elsewhere (Paquet et al., 2013). POS were defined as parcels larger than a typical urban house block (700 $m^2$) used as sporting facilities, reserves, national parks, conservation reserves, or botanic gardens.

### 2.2. Analyses

Poisson regression models were used to calculate the relative risks (RR) of developing each risk factor for participants free of the same risk factor at baseline. Two sets of models were estimated. Models 1a and b tested associations with RFEI, the walkability score and the number of POS. Models 2a and b tested the associations with POS median size, type and greenness. The latter set excluded participants without a proximal POS ($n$=61). Analyses accounted for spatial clustering by State Suburb (Australian Bureau of Statistics Census Geographic Area) through the use of Generalised Estimating Equations (GEE) estimation in addition to participants' gender, age, household income ($<$20,000AUD, 20,000–60,000AUD, $>$60,000AUD), education (university graduate or not), duration of follow-up and area-level socio-economic deprivation (Australian Bureau of Statistics, Socio Economic Indexes for Areas Index of Relative Socio-economic Disadvantage). No evidence of multicollinearity was found (variance inflation factors (VIF's)$<$2.0). Continuous predictors were standardised. Statistical significance was set at alpha$<$0.05.

## 3. Results

A total of 3145 participants had a complete geo-referenced record, covariate information and clinical data at baseline and follow-up. The mean follow up period was 3.5 years (SD: 1.1). Socio-demographic and clinical baseline characteristics of the sample are presented in Tables 1. Incidence rates were 24.7% for pre-diabetes/diabetes, 24.7% for hypertension, 21.7% dyslipidaemia, and 26.4% for abdominal obesity.

Incident abdominal obesity was associated with the relative unhealthfulness of the food environment (RFEI, see Table 2). A one standard deviation increase in the index was associated with an 11% higher risk of becoming abdominally obese. Incident pre-diabetes/diabetes was associated with walkability score and median POS size. Specifically, a one standard deviation increment in walkability score and median POS size was associated with a 12% and 25% lower risk of developing pre-diabetes or diabetes, respectively, over the follow-up period. No statistically significant associations were found for hypertension or dyslipidaemia. However, a marginally statistically significant positive association between POS greenness and dyslipidaemia was found.

## 4. Discussion

Results suggest that built environmental attributes promoting an active lifestyle or hindering a healthful diet are differentially