Patterning of neighbourhood food outlets and longitudinal associations with children's eating behaviours☆

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ABSTRACT

This study examined cross-sectional and prospective associations between typologies of neighbourhood food environment and dietary patterns among 10–12 year-old children. Baseline data were collected in 2003 and follow-up data in 2006 from children in Melbourne or Geelong. Parents completed a food frequency questionnaire at both time points. 'Healthful' and 'energy-dense' dietary pattern scores were computed. A Geographic Information System was used to determine the presence or absence of food outlets (cafés/restaurant; fast food; supermarkets/grocery stores; convenience store; greengrocer; and butcher, seafood or poultry retailer) within an 800 m road network buffer of home. Three typologies were identified: 1-variety of food outlets, including those selling core/fresh foods ($n = 96$); 2-café/restaurant and convenience ($n = 160$); 3-few types of outlets ($n = 208$). Latent class analysis was used to identify underlying unobservable typologies of neighbourhood food outlet availability. Linear mixed models were fitted to determine cross-sectional ($n = 439$) and longitudinal ($n = 173$) associations between the three identified neighbourhood typologies and each (log-transformed) dietary pattern, accounting for clustering within families and schools. There was little evidence of cross-sectional associations. The longitudinal analyses showed that compared to those with a variety of food outlets, those with few types had 25% lower scores for the healthful dietary pattern ($p < 0.05$) three years later. For optimal dietary patterns, availability of a variety of food outlets close to home, particularly those where core/fresh foods are available, may be important.

1. Introduction

The diets of Australian children and adolescents are less than optimal, characterised by too few serves of fruits and vegetables, grains, dairy and lean meats and alternatives, and excess consumption of free sugars from discretionary foods and drinks (Australian Bureau of Statistics, 2016a; Australian Bureau of Statistics, 2016b). Recent national data, for example, show that fewer than 1% of 9–18 year-olds met guidelines for vegetable intake and for lean meats and alternatives (Australian Bureau of Statistics, 2016a), and almost three in four derived at least 10% of their dietary energy from free sugars (Australian Bureau of Statistics, 2016b). Consumption of sugar-sweetened beverages (SSB) and too few fruits and vegetables have been linked to overweight and obesity and poorer cardiometabolic health in children and youth (Funtikova et al., 2015).

While determinants of diet are complex and multi-factorial, the availability and accessibility of particular types of food stores are widely considered to play a role (Rahmanian et al., 2014). These may exert particular influence as children gain autonomy during the transition to adolescence when they have more control over their food choices and influence on the food available within their homes. A number of studies have found evidence of associations between accessibility of particular types of outlets close to home and dietary outcomes, but the findings have been inconsistent. To date, studies have shown accessibility of fast food outlets and/or convenience stores to be positively associated with fast food purchasing (He et al., 2012a) and consumption (Berge et al., 2014), consumption of SSB (Hearst et al., 2012; Laska et al., 2010) and sweets (Lamichhane et al., 2012), fewer serves of fruit and of vegetables (Timperio et al., 2008) and a lower frequency of consuming "healthy" foods and higher frequency of consuming "unhealthy" foods (Carroll-Scott et al., 2013) among children or adolescents. Other studies have found proximity to grocery stores and supermarkets to be associated with healthy eating (Lamichhane et al., 2012; Smith et al., 2013) and greater SSB consumption (Hearst et al., 2012; Laska et al., 2010). However, not all studies have found associations between aspects of the neighbourhood food environment and dietary outcomes, not all associations have been in the expected direction, and associations have not been observed for all dietary

indicators examined (Ding et al., 2012; An and Sturm, 2012; Timperio et al., 2009).

The evidence base is mainly limited to cross-sectional studies of associations between the availability of specific types of food outlets and dietary outcomes. However, food outlets generally do not exist in a neighbourhood in isolation, but rather in combination with other food outlets; approaches that consider the complexity of such neighbourhood environments are needed (Feuillet et al., 2016). Among adolescents, Ding et al. (2012) created sub-scales based on self-reported time to travel to 'healthful' store types (supermarkets, fruit/vegetable markets and non-fast food restaurants) and 'less-healthful' store types (convenience stores and fast-food restaurants), while Berge et al. (2014) created a summary score based on the availability of fast food outlets, conveniences stores and supermarkets/super stores. A variety of researcher-driven approaches have been used in studies among adults, including outlet diversity scores based on the number of different types available (McInerney et al., 2016; Minaker et al., 2013; Stark et al., 2013), proportion of "healthy" and "unhealthy" outlets (Stark et al., 2013) and indices based on outlet types (McInerney et al., 2016; Spence et al., 2009). These approaches typically include a narrow range of outlets. A further limitation is that the methods used to compute the summary scores can result in the same score for different combinations of outlets (Lamb et al., 2015).

Data-driven approaches such as cluster-based statistical techniques have been applied to determine patterns or typologies of neighbourhood features relevant to physical activity (e.g. Charreire et al., 2012; Adams et al., 2011; Norman et al., 2010; Roemmich et al., 2007), but have rarely been applied to characterise food environments. Such data-driven approaches are suitable for characterising food environments because they can identify different combinations of food outlets, resulting in a description of how food outlets pattern in neighbourhoods. To our knowledge, no studies have examined associations between neighbourhood food typologies and dietary patterns in children or youth. In addition, most research on food environments and diet has examined associations with individual foods or food groups; few studies consider the broader diet, such as indices of diet quality (Carroll-Scott et al., 2013; Smith et al., 2013; He et al., 2012b). The aims of this study were to identify neighbourhood typologies based on objectively-assessed availability of different types of food outlets, and to examine cross-sectional and three-year longitudinal associations with dietary patterns among 10–12 year-old children. The findings can inform urban planning policy.

2. Methods

Cross-sectional and longitudinal analyses were conducted using data from the 10–12 year old children who participated in the Health, Eating and Play Study (HEAPS). The study was approved by the Deakin University Human Research Ethics Committee. The Department of Education and Training Victoria and the Catholic Education Office approved data collection via schools.

2.1. Participants

In 2003, children in Grades 5 and 6 (two final years of primary (elementary) school) within 15 primary schools in Melbourne and Geelong, Victoria, Australia were approached to participate in a cross-sectional study (Salmon et al., 2006). Schools were randomly selected from a list of schools with ≥ 200 enrolled students located in postcodes within each of the lowest, middle and highest quintiles of the Socioeconomic Index for Areas Index of Relative Disadvantage 2001 (Australian Bureau of Statistics, 2003) and approached to participate. Children took recruitment packages home for a parent/guardian and parents provided written consent for their own and their child's participation in the study. Overall, 947 children in Grades 5 and 6 took part in the initial cross-sectional study (46% response rate). Of these, 474

parents agreed to be recontacted in the future (considered the baseline sample for this paper) and they and their child were subsequently invited to take part in a follow-up study three years later. Full written parental consent was again required and 197 families took part.

2.2. Measures

2.2.1. Dietary patterns

At baseline and the three year follow up, parents completed a food frequency questionnaire (FFQ) about the frequency their child ate specific foods and beverages over the past week. Principal components analysis (PCA) was performed on the baseline dietary data, as described by Leech et al. (2014). In brief, PCA with varimax rotation was performed on 22 food and beverage groups that were included in the FFQ at both time points. The number of components to extract was determined by Eigenvalues > 1, scree plot and interpretability, and food groups/items with factor loadings of ≥ 0.25 that did not cross-load with another component were selected to comprise each component. Two distinct dietary patterns were found: a 'healthful' and an 'energy-dense' pattern. A summed score was computed for each pattern at baseline and follow-up after weighting the daily frequency of consumption of the food item or group by the component loadings. The energy-dense pattern was characterised by energy-dense sweet and savoury foods and high energy beverages (e.g. savoury flavoured biscuits, potato chips, sweet cakes and pastries, energy-dense beverages). The healthful pattern was characterised by fruit, dried fruit, vegetables (excluding potatoes), reduced-fat milk and water (Leech et al., 2014). Higher scores for the healthful pattern indicate higher consumption of healthful food compared to lower scores, while higher scores for the energy-dense pattern indicate higher consumption of energy-dense foods compared to lower scores. Although these baseline and follow-up scores were computed based on PCA conducted at baseline, Leech et al. (2014) reported consistency in dietary patterns generated at follow-up when the PCA was repeated ($r = 0.89$ for the energy-dense pattern; $r = 0.78$ for the healthful pattern).

2.2.2. Neighbourhood food environment

A Geographic Information System (GIS) was used to determine availability of eight initial types of food stores within an 800 m road network buffer around participants' homes at baseline (packages ArcView 3.3, ESRI Redlands, 2002 and ArcMap 9, ESRI, Redlands, 2005 and related extensions). This distance is considered by parents of 10–12 year-old children to be a walkable distance for their child (Timperio et al., 2004). Locations of butchers, poultry and seafood outlets were sourced from Primesafe (compulsory register these types of retailers). Other types of food outlets were sourced from food premise registers maintained by local government for 90% of the baseline sample and from electronic databases (e.g. telephone directories) and online and printed dining guides for the remainder of the sample (Timperio et al., 2008). The eight food outlet types included: cafés/restaurants/takeaway; fast food outlets (eight most common chains in Victoria at the time (Timperio et al., 2008)); bakeries and cake stores; major supermarket chains; small supermarkets/grocery stores; greengrocers; convenience stores; and butcher, seafood or poultry retailers. These outlets were selected as they cover all food stores where core food items and meals can be purchased. Locations of food outlets were geocoded and the presence or absence of each type of food outlet within each 800 m buffer was computed.

2.2.3. Potential covariates

Maternal education was included as a marker of socioeconomic position (SEP) assessed via parent report of their own (if the female carer was the respondent) or their female partners' highest level of education (if a male carer was the respondent), and collapsed into three categories: high (university or tertiary education); medium (completed high school or vocational training); and low (less than high school).