Health Promoting Community Design; Nutrition; Weight Control; Youth

Associations Between Childhood Obesity and the Availability of Food Outlets in the Local Environment: A Retrospective Cross-Sectional Study

Laura J. Miller, PhD; Sarah Joyce, PhD; Shannon Carter, BSc; Grace Yun, PhD

Abstract

Purpose. *Examine whether individual-level childhood obesity is related to residential availability of fast food and healthy food outlets.*

Design. *Retrospective cross-sectional study.*

Setting. *Perth, Western Australia*

Subjects. *A total of 1850 children aged 5 to 15 years in 2005–2010 who participated in the Western Australian Health and Wellbeing Surveillance System survey.*

Measures. *Geographical Information Systems were used to calculate a range of measures of fast food and healthy food outlet access and availability. For example, distance to nearest and access and density measures within 800 m and 3 km of each child's residence were all tested.*

Analysis. *Multivariate logistic regression analysis, controlling for individual-level sociodemographic factors and lifestyle behaviors.*

Results. *An increasing number of healthy food outlets within 800 m of a child's home was associated with a significantly reduced risk of being overweight/obese in all models tested. After controlling for age, physical activity, time spent sedentary, weekly takeaway consumption, area disadvantage, and count of fast food outlets, each additional healthy food outlet within 800 m was associated with a 20% decrease in the likelihood of a child being overweight or obese (odds ratio: .800, 95% confidence intervals: .686–.933).*

Conclusion. *The local food environment around children's homes has an independent effect on child weight status. These findings highlight the importance of the built environment as a potential contributor towards child health, which should be considered when developing community health promotion programs. (Am J Health Promot 2014;28[6]:e137–e145.)*

Key Words: Obesity, Child, Fast Food, Healthy Food, GIS, Logistic Models, Prevention Research. Manuscript format: research; Research purpose: modeling/relationship testing; Study design: nonexperimental; Outcome measure: morbidity; Setting: local community; Health focus: nutrition; Strategy: built environment; Target population age: youth; Target population circumstances: geographic location

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PURPOSE

The World Health Organization describes childhood obesity as one of the most serious public health challenges of the 21st century.[1] In Australia, childhood obesity rates are one of the highest among developed nations, with around 25% of Australian children currently overweight or obese.[2] In Western Australia, the figure is slightly lower (22.3%), but still a cause for concern.[3] Children who are overweight or obese are more likely to be overweight or obese as adults, and have an increased risk of developing both short- and long-term health conditions, including cardiovascular disease and type 2 diabetes.[4,5]

There are likely to be multiple causes of obesity, including an interplay between both genetic and environmental risk factors.[6] However, increasing emphasis is being placed on preventing obesity through non-genetic influences such as physical activity and diet.[7] Physical activity and diet have both been related to childhood obesity rates in a number of settings.[8–10] Children's physical activity levels have decreased over recent decades because of increases in car, television, Internet, and game console use.[11,12] In Western Australia, only half of children meet the recommended amount of physical activity levels and over one-quarter exceed the national guidelines for sedentary activity.[3]

Australian diets have also changed, with higher intake of energy-dense foods and lower fruit and vegetable consumption.[13] Nearly half of Western

Australian children consume fast food (FF) or takeaway at least once a week, but only 4 in 10 consume the recommended daily amount of vegetables.[3] A study in Melbourne found that children with a greater number of FF and convenience outlets close to home had a lower likelihood of consuming fruit or vegetables more than twice a day.[14]

A number of studies have examined the relationship between adult obesity and FF outlet location, with mixed findings.[15–17] Fewer studies have concentrated on individual-level childhood obesity and the availability of FF outlets in the local environment. The few that exist primarily use U.S. and U.K. data, and taken together, the findings are relatively inconclusive.

Two U.S. studies found no association between proximity to FF outlets and obesity in children. In Cincinnati, Ohio, the associations between overweight status in low-income preschool children and FF restaurant proximity were examined adjusting for household income, child ethnicity and sex, playground proximity, and neighborhood safety.[18] A national-level study in the United States examined the relationship between the change in children's body mass index (BMI) over 4 years and the local food supply, including density of outlets and food prices. No significant relationship was found between childhood obesity and food outlet density (grocery stores, convenience stores, full-service restaurants, and FF restaurants) in the child's home or school zip code areas.[19]

Several studies in the United States have found that FF outlets tend to be concentrated around schools.[20,21] In addition, a Californian study found that high school students with FF restaurants within half a mile of their schools were significantly more likely to be overweight or obese.[22] A more recent study in Virginia revealed that school students who resided within one-tenth or one-quarter of a mile from a FF restaurant had significantly higher BMI values.[23]

In the United Kingdom, a recent study in Leeds found that children living in areas with a higher density of FF outlets were more likely to be obese or overweight/obese, after controlling for age, sex, and deprivation score.[24] There was a 1% increase in risk of obesity for each additional FF outlet in their area of residence. However, the only published study in Australia observed that children aged 13 to 15 years with at least one FF outlet within a 2 km buffer of their homes in Melbourne had lower BMI z-scores. In girls, the likelihood of being overweight/obese was reduced by 80% if they had at least one FF outlet within 2 km of their home, and by a further 14% with each additional outlet within 2 km. The authors found these findings hard to explain, but proposed that areas with many FF outlets may also contain other food outlets selling healthier options.[25]

Limitations of previous studies exploring access to FF include the use of narrow definitions of FF[15,18,25] and the use of approximate distance measures (e.g., Sturm and Datar,[19] Mellor et al,[23] and Fraser and Edwards[24]). Furthermore, with the exception of emerging work in California and Canada,[26,27] few studies also examine the effects of healthy food (HF) access in their models.

This study aims to examine whether a relationship exists between childhood overweight/obesity and geographic proximity to food outlets in a previously unexplored setting, Perth, Western Australia, while accounting for a number of individual-level predictors for high BMI. This research provides further contributions to existing knowledge by incorporating measures of HF access, using a more inclusive definition of FF, using exact locations for child residences and food outlets, and calculating distances along the road network to gain a more precise measure of food outlet availability.

METHODS

Design

This study is a retrospective cross-sectional study, with data collected between 2005 and 2010. The study area was the metropolitan area of Perth in Western Australia (as defined by the Department of Health, Western Australia), which covers 8092 km^2 of the state and which had an overall population of approximately 1.8 million people in 2010, of which almost 250,000 were children aged 5 to 15 years.[28]

Sample

The study sample consisted of 1850 children aged 5 to 15 years who participated in the Western Australian Health and Wellbeing Surveillance System (WA HWSS) between 2005 and 2010. The WA HWSS is a continuous data collection system that was developed to monitor the health and wellbeing of Western Australians. A representative sample of the population is randomly selected from the white pages telephone book and approached to participate in a computer-assisted telephone interview. A parent or guardian responds to questions on behalf of his or her child about the child's height and weight, levels of physical activity, nutritional behaviors, and sociodemographic characteristics. Questions used in the WA HWSS are drawn from a number of published sources and have been developed and tested for reliability and validity for use over the telephone. The residential address of respondents is routinely geocoded (assigned latitude and longitude locations) to allow geographical analysis of the survey results. The surveillance system consistently attains a response rate of over 85% and thus can be considered representative of the general population.[29]

Measures

A number of individual-level variables were extracted from the WA HWSS, including information on fruit and vegetable consumption, physical activity, breastfeeding, socioeconomic status including family structure, income, private insurance, BMI, and the subsequent classification of the child as overweight, obese, or neither. The BMI was calculated from the child's height and weight as provided by the parent, after the removal of outliers and biologically implausible values.[30] Age- and sex-specific BMI categories developed by the United States Centers for Disease Control and Prevention were used to classify each child as overweight, obese, or neither overweight nor obese.[31] Additionally, children were classified as born either in Australia or overseas.

Each child was also assigned an area-level disadvantage measure according to residential address. The Socio-Economic Indexes for Areas (SEIFA)

Index of Relative Socio-Economic Disadvantage was used in this study and provides a measure of relative socioeconomic disadvantage based on Census data including low income, low educational attainment, unemployment, and dwellings without motor vehicles.[32]

Western Australia does not currently have a centralized list of food outlets. However, the Food Act 1984 requires that all food premises be registered with the Local Government Authority (LGA) they fall within. As a result, the food premise information was obtained by contacting the 33 LGAs within the study area and requesting a list of food premises within their jurisdiction, along with address data. These datasets were then standardized and geocoded using the ArcGIS 9.3 desktop application ArcMap. The names and descriptions of the premises were used to categorize the establishments by type. A sample of the food premises was verified using Internet search engines of business listings, and a limited number were verified by site visits.

The majority of previous studies use a narrow definition of FF that includes only international and national FF chain outlets.[15] This study sought to address this limitation and included both multinational and locally operated FF outlets, using a similar definition to Pearce et al.[33] We included all of the well-known multinational FF chain outlets and also all takeaway establishments, which included, for example, locally owned Chinese, Indian, and Thai restaurants; fish and chip shops; burger bars; and pizzerias. Furthermore, this work considered the influence of HF options in the vicinity of the child's home by including a measure of HF access. We defined HF outlets as supermarkets, general stores, fruit and vegetable stores, and butchers, as these premises provide significant options for the purchase of HF. Where uncertainty existed over the type of food establishment, these were checked via online search engines to determine their inclusion in the FF or HF categories.

A number of measures of HF and FF outlet access/availability were created using network analysis within ArcMap:

Table 1
Descriptive Statistics of the Continuous Food Outlet Variables*

Variable (N = 1850)	Median	Mean	SD	Minimum	Maximum
Distance to closest FF outlet, m	931.0	1340.5	2168.7	2.3	29,560.3
Distance to closest HF outlet, m	1072.4	1481.5	1994.2	12.0	29,914.5
Count of FF outlets within 800 m	0.0	1.7	3.4	0.0	35.0
Density of FF outlets within 800 m	0.0	2.0	3.8	0.0	37.3
Count of HF outlets within 800 m	0.0	0.6	1.2	0.0	8.0
Density of HF outlets within 800 m	0.0	0.8	1.5	0.0	13.4
% of HF outlets within 800 m	0.0	12.8	24.2	0.0	100.0
Count of FF outlets within 3 km	21.0	27.5	27.9	0.0	289.0
Density of FF outlets within 3 km	2.0	2.2	1.8	0.0	18.9
Count of HF outlets within 3 km	8.0	10.3	8.2	0.0	49.0
Density of HF outlets within 3 km	0.8	0.8	0.5	0.0	2.8
% of HF outlets within 3 km	27.5	28.3	14.1	0.0	100.0

* FF indicates fast food; and HF, healthy food.

Distance to Closest. Road network distances (in meters) from each child's residence to the nearest FF outlet and the nearest HF outlet were calculated using network analysis.

Access to at Least One. Binary access variables to measure the presence of both FF and HF outlets within 800 m (10-minute walk) and 3 km (typical driving distance to local stores)[34] along the road network from each residence were also computed.

Count/Density. The counts of FF and HF outlets within both 800 m and 3 km network buffer distances were also derived. Densities of FF and HF outlets were calculated in network buffer distances of 800 m and 3 km by dividing the count of FF and HF outlets by the land area of the buffers.

Percentage of HF Outlets. Because the locations of HF and FF outlets were strongly correlated in the Perth metropolitan area, we also created a relative measure of HF access[35]—the percentage of HF outlets within 800 m and 3 km of each residence. This was calculated as: count of HF outlets ÷ (count of HF + FF outlets) * 100.

Analysis

A number of methods were employed to analyze these data. First, descriptive statistics of all variables were examined. Next, univariate logistic regression models were fitted with overweight/obese status as the outcome variable (results not shown). A series of multivariate regression models was then constructed to examine the association between overweight/obese status and proximity to the food outlets after controlling for the remaining explanatory variables. The multivariate models were based on the univariate model findings and previous studies.[36,37]

To begin with, a multivariate model was constructed for each of the food outlet measures listed in Tables 1 and 2. The food outlet variables were initially kept in separate models, as they were significantly correlated (for example the density of FF outlets and HF outlets within 3 km had a Spearman's rank correlation coefficient of .8). Each model included all of the sociodemographic factors, early life influences, and lifestyle behaviors that were significantly related to childhood obesity ($p < .05$) in the univariate models: family structure, SEIFA quintile of residence, private insurance category, physical activity, sedentary behavior, and takeaway consumption. Age was also included, as it was borderline significant in the univariate model ($p = .061$) and the prevalence of obesity has been shown to vary between different age groups.[37] Fruit and vegetable intake were not included in the multivariate models as they were not significant predictors of childhood obesity in the univariate models, and the recommended

Table 2
Number and Percentage of Study Participants by Food Outlet Access Variable*

Access Variable	No.	%
Access to at least 1 FF outlet within 800 m	763	41.2
Access to at least 1 HF outlet within 800 m	548	29.6
Access to at least 1 FF outlet within 3 km	1750	94.6
Access to at least 1 HF outlet within 3 km	1728	93.4

* FF indicates fast food; and HF, healthy food.

amount of intake varies for different age groups within childhood.[36] Checks for multicollinearity revealed that the variables family structure and private insurance category were introducing significant multicollinearity into the models, and were subsequently removed.

The final set of multivariate models contained corresponding FF and HF outlet variables in the same model. For example, when examining the effect of the FF outlet counts within 800 m, we also controlled for the count of HF outlets within 800 m. Although the presence of fast food options may be associated with childhood weight status, the presence of HF outlets may confound this relationship, and these potential associations required investigation. Interaction effects between the food outlet variables were also investigated. No multicollinearity was found in the final multivariate models. The parameters for the density variables are not reported as they showed similar findings to the count variables.

Analysis of the survey dataset was approved by the Western Australia Department of Health Research Ethics Committee.

RESULTS

Twenty-two percent of the children sampled (n = 1850) were either overweight or obese for their age. Around 16% of the children sampled were overweight, and almost 6% were obese (Table 3). A total of 2415 FF outlets and 899 HF outlets were identified and geocoded with similar spatial distributions (Figure). The mean distance to the nearest FF outlet was 1.3 km, and the mean number and density of FF outlets within 3 km of respondents' homes were 27.5 and 2.2 respectively (Table 1). In the Perth metropolitan area as a whole, there were 1.4 FF outlets per 1000 population. The mean distance to the nearest HF outlet was 1.5 km and the mean number and density of HF outlets within 3 km of respondents' homes were 10.3 and .8 respectively (Table 1). There were .5 HF outlets per 1000 population in the Perth metropolitan area. Thirty percent of children had at least one HF outlet within 800 m of their home, whereas 41% had at least one FF outlet within the same distance (Table 2).

Table 4 presents descriptive statistics of the study participants and the univariate control variables associated with overweight or obese classification. The respondents were split evenly between males and females and had an average age of 10.8 years. The majority of respondents were born in Australia (89%). Over half of respondents were from the two "least disadvantaged" SEIFA quintiles and four in five children lived with both parents. On average, children spent 9.0 hours a week in physical activity and 13.4 hours in sedentary activities. Respondents reported eating an average of 1.0 takeaway meals per week and 2.5 servings of vegetables and 2.0 servings of fruit daily. Univariate regression analysis of the sociodemographic and health variables indicated that sole-parent families, no private health insurance, socioeconomic disadvantage, and more time spent in sedentary activities were independently associated with an increased risk of the child being overweight or obese.

After adjusting for the control variables, children with access to at least one HF outlet within 800 m of their home had a 38% decreased risk of being overweight/obese compared to those with no HF outlet within 800 m (Table 5). Each additional HF outlet within the 800 m buffer was associated with a 19% decrease in the risk of being overweight or obese. Using a 3 km buffer distance, each additional HF outlet was associated with a 2% decrease in the likelihood of the child being overweight or obese (Table 5). The relative measure of HF availability (percentage of HF outlets) was only significantly related to child weight status using an 800 m buffer. For every additional percentage of HF outlets within this distance, the risk of a child being overweight or obese decreased by 1% (Table 5).

Children with access to at least one FF outlet within 800 m had a 31% decreased risk of being overweight or obese, compared to those with no FF outlet within 800 m of their home (Table 5). However, increasing counts of FF outlets within 800 m were not significantly related to child weight status at this distance. Using a 3 km buffer, each additional FF outlet was associated with a 1% decrease in the likelihood of the child being overweight or obese (Table 5).

Table 3
Number and Percentage of Study Participants by Overweight/Obesity Category

Overweight/Obese Category	No.	%
Not overweight or obese	1440	77.8
Overweight or obese	410	22.2
Overweight	303	16.4
Obese	107	5.8
Total	1850	100

Figure
Density of Food Outlets by Type in Perth, Western Australia

Since the equivalent HF and FF outlet variables were highly correlated and independently related to the outcome variable, we also examined the effects of including both variables in the same model. We found no significant relationships when examining the HF and FF access variables in the same multivariate model, using either the 800 m or 3 km buffer. The previously noted negative association between access to at least one FF outlet within 800 m and overweight/obesity disappeared after inclusion of the HF access variable in the model. Furthermore, the negative relationship between FF outlet count within 3 km and the outcome variable was also removed after adjustment for the HF outlet count within 3 km (results not shown).

However, the count of HF outlets within 800 m remained significantly associated with a decreased risk of childhood overweight/obesity, even after controlling for FF outlet count. Each additional HF outlet within 800 m was associated with a 20% decrease in the likelihood of the child being overweight or obese (Table 6). There was no relationship at the 3 km level (results not shown). No significant interaction effects were noted between the FF outlet and HF outlet variables in any of the models. The final multivariate models, which included both food outlet variables together with the control variables, explained 5% to 7% of the total variation in weight status in our sample of children.

DISCUSSION

Our study examined the association between residential proximity to both FF and HF outlets and the body weight of 1850 children in the Perth metropolitan area. We found that the count of HF outlets within 800 m was consistently associated with a decreased risk of children being overweight or obese. This relationship was noted when the HF outlet variable was modeled alone, after adjusting for known individual-

Table 4
Univariate Logistic Regression Results for Control Variables, With the Likelihood of Being Overweight/Obese as the Dependent Variable

	No.	%	*p*	OR	LCI	UCI
Categorical Variables						
Sex						
Female	899	48.6	0.7170	0.960	0.771	1.196
Male (REF)	951	51.4	—	—	—	—
ATSI category						
Yes	17	0.9	0.1981	1.929	0.709	5.249
No (REF)	1833	99.1	—	—	—	—
Australian born						
No	212	11.5	1.0000	1.000	0.709	1.444
Yes (REF)	1638	88.5	—	—	—	—
Family structure category						
Other family structure	20	1.1	0.5166	0.665	0.194	2.282
Sole parent family	220	11.9	0.0046	1.578	1.152	2.164
Step or blended family	124	6.7	0.4035	1.201	0.782	1.845
Child living with both parents (REF)	1486	80.3	—	—	—	—
Income category						
Refused to answer	29	1.6	0.1314	1.866	0.830	4.198
Don't know/unsure/can't remember	72	3.9	0.5726	0.829	0.433	1.589
Under $20,000	58	3.1	0.0759	1.719	0.945	3.128
$20,001–$40,000	181	9.8	0.0810	1.412	0.958	2.082
$40,001–$60,000	223	12.1	0.0541	1.423	0.994	2.038
$60,001–$80,000	334	18.1	0.1011	1.306	0.949	1.796
$80,001–$100,000	315	17.0	0.6624	1.078	0.770	1.508
Greater than $100,000 (REF)	638	34.5	—	—	—	—
Private insurance category						
Don't know/unsure/can't remember	6	0.3	0.0972	3.905	0.781	19.533
None	530	28.7	0.0044	1.457	1.124	1.888
Hospital only	450	24.3	0.9070	1.017	0.763	1.356
Ancillary only	89	4.8	0.1241	0.609	0.323	1.146
Both hospital and ancillary (REF)	775	41.9	—	—	—	—
SEIFA disadvantage category						
SEIFA quintile 1—most disadvantaged	133	7.2	0.0002	2.231	1.474	3.376
SEIFA quintile 2	243	13.1	0.0058	1.634	1.153	2.317
SEIFA quintile 3	255	13.8	0.0780	1.375	0.965	1.959
SEIFA quintile 4	550	29.7	0.0150	1.416	1.070	1.875
SEIFA quintile 5—least disadvantaged (REF)	669	36.2	—	—	—	—
Continuous variables						
Age	1850	10.8	0.0613	0.967	0.934	1.002
Physical activity in previous week, min	1482	538.7	0.0041	1.000	0.999	1.000
Time spent sedentary in previous week, h	1845	13.4	0.0052	1.019	1.006	1.033
Daily vegetable servings, No.	1847	2.5	0.9124	0.995	0.917	1.081
Daily fruit servings, No.	1849	2.0	0.2071	0.938	0.850	1.036
Weekly takeaway consumption, No.	1372	1.0	0.0252	1.000	0.999	1.000

* OR indicates odds ratio; LCI, lower confidence interval; UCI, upper confidence interval; ATSI, Aboriginal and Torres Strait Islander; REF, reference category; and SEIFA, Socio-Economic Indexes for Areas.

level predictors of obesity, and after controlling for the presence of FF establishments. In the latter model, the risk of a child being overweight or obese decreased by 20% with every additional HF outlet present.

The majority of previous research focuses on proximity to unhealthy food outlets. However, work is beginning to emerge demonstrating the importance of residential access to HF options. For example, studies in the United States and Canada suggest that the presence of HF via grocery stores can protect against obesity in adults,[27,38–41] so it follows that a similar relationship might be found in children. Individuals who have greater access to HF options may be more likely to choose to consume HF, contributing to a healthier weight. For children, this probably reflects a choice taken by their parents on their behalf.[42,43] Furthermore, a recent study conducted in Norfolk, United Kingdom, found that availability of HF outlets within 800 m of their home was associated with lower BMI in a population-based sample of 9- to 10-year-olds.[44]

In 2 of our 12 initial multivariate models, the availability of FF outlets was negatively associated with childhood overweight/obesity. However, after adjusting for the presence of HF outlets, we found no significant relationship between any of the FF outlet variables and child weight status. It is likely that the HF outlet variables were confounding the relationship between the FF outlet variables and child weight status. The count of HF outlets was strongly related to the count of FF outlets within both 800 m and 3 km of children's homes, and the count of HF outlets was also independently related to the likelihood of the child being overweight/obese.

In the final multivariate models, we found no significant associations between the food outlet variables and obesity using a 3 km buffer, which suggests that the immediate environment around a child's home is more important than areas located at greater distances. As Fraser and Edwards[24] note, the local neighborhood may be more influential to the dietary habits of children because of their limited ability to travel independently. It may also reflect a preference by their parents to do the household food shopping close to home for convenience. Previous studies on childhood obesity in the United States have found significant relationships with FF outlet availability using distances equal to or less than .5 miles (around 800 m),[22,23] lending support to these theories. In line with previous studies,[18,24,25] there was also no significant relationship between the distance to the nearest FF or HF outlet and a child's overweight/obese status in the Perth metropolitan area. After adjustment for all possible confounding variables, no significant associations were shown between

Table 5
Multivariate Logistic Regression Results for Food Outlet Variables, With the Likelihood of Being Overweight/Obese as the Dependent Variable*

Variable	*p*	OR	LCI	UCI
Distance to closest FF outlet	0.3820	1.000	1.000	1.000
Distance to closest HF outlet	0.0855	1.000	1.000	1.000
Access to at least 1 FF outlet within 800 m, yes	0.0068	0.691	0.529	0.903
Access to at least 1 HF outlet within 800 m, yes	0.0020	0.620	0.458	0.839
Count of FF outlets within 800 m	0.0904	0.961	0.919	1.006
Count of HF outlets within 800 m	0.0012	0.808	0.710	0.920
% of HF outlets within 800 m	0.0102	0.992	0.986	0.998
Access to at least 1 FF outlet within 3 km, yes	0.4080	0.793	0.458	1.373
Access to at least 1 HF outlet within 3 km, yes	0.4163	0.812	0.492	1.341
Count of FF outlets within 3 km	0.0180	0.993	0.988	0.999
Count of HF outlets within 3 km	0.0084	0.978	0.961	0.994
% of HF outlets within 3 km	0.9352	1.000	0.991	1.009

* Each food outlet variable is modeled separately and each model is adjusted for age, Socio-Economic Indexes for Areas area of residence, physical activity, sedentary activity, and takeaway consumption. OR indicates odds ratio; LCI, lower confidence interval; UCI, upper confidence interval; FF, fast food; and HF, healthy food.

childhood overweight/obesity and any of the food outlet access variables. Therefore, it was exposure to a greater number of HF options within short distances that was the most important food outlet availability measure for predicting child weight status in our study population.

These findings must take into account several limitations of the study, including the cross-sectional design, which restricts our ability to draw inferences on causality. For example, it is possible that other individual-level or local environmental factors are contributing to the relationships found. The final multivariate models explained only a small proportion of the total variation in the weight status of the children sampled. Access to healthy/unhealthy foods may also be achieved at other locations, for example close to a child's school or parent's workplace, or somewhere in between. Future research could explore the measurement of the activity spaces[45] of Perth children and their parents to test the assumption that exposure to healthy/unhealthy food choices close to home is the most important exposure. Furthermore, varied definitions of FF/HF outlets may lead to different findings, and this requires testing in further work. Finally, classification of excess body weight was based on self-reported height and weight measurements and could not be validated. However, it is reasonable to assume that any measurement error would be non-directional and unlikely to be spatially related.

A significant strength of the study was its capacity to control for a variety of individual variables known to be associated with obesity, including physical activity, diet, and sedentary behavior. The significant associations in our models remained even after adjustment for area-level disadvantage, which has been identified as a key determinant in the spatial disparities of HF access in a number of other settings.[33,46,47]

Having latitude and longitude locations for food outlets and each study participant's residence also allowed for more precise spatial measures to be calculated, as opposed to lower-resolution geographies such as super-output areas and zip codes that have been used in other studies.[19,24] In addition, the response rate to the survey was extremely high (80+%), limiting the likelihood of selection bias and making the results generalizable to the broader Perth metropolitan child population.

Finally, our ability to examine both HF and unhealthy food options is a considerable improvement on previous work. It was of particular importance when considering the impact of HF availability on the relationship between FF and overweight/obesity and vice versa. Our results suggest that future studies should endeavor to examine as much of the food environment around individuals' homes/schools/workplaces as possible when exploring associations with excess body weight. In addition, improved methodologies could include the use of multilevel models to identify the different levels at which risk factors for obesity operate. Furthermore, longitudinal studies that incorporate measures of temporal

Table 6
Multivariate Logistic Regression Results for 800 m Food Outlet Variables, With the Likelihood of Being Overweight/Obese as the Dependent Variable*

Variable	*p*	OR	LCI	UCI
Age	0.0036	0.938	0.899	0.979
SEIFA disadvantage category				
SEIFA quintile 1—most disadvantaged	0.0058	2.074	1.235	3.484
SEIFA quintile 2	0.0050	1.768	1.187	2.632
SEIFA quintile 3	0.2853	1.258	0.826	1.917
SEIFA quintile 4	0.0278	1.440	1.040	1.992
SEIFA quintile 5—least disadvantaged (REF)	—	—	—	—
Physical activity in previous week, min	0.0079	1.000	0.999	1.000
Time spent sedentary in previous week, h	0.0016	1.028	1.010	1.046
Weekly takeaway consumption, No.	0.0508	1.000	0.999	1.000
Count of FF outlets within 800 m	0.8050	1.006	0.956	1.059
Count of HF outlets within 800 m	0.0044	0.800	0.686	0.933

* OR indicates odds ratio; LCI, lower confidence interval; UCI, upper confidence interval; SEIFA, Socio-Economic Indexes for Areas; REF, reference category; FF, fast food; and HF, healthy food.

exposure to different food and local environments are also recommended.

Our findings suggest that the local food environment around children's homes has an independent effect on child weight status. In particular, an increased number of HF outlets within 800 m of children's homes was associated with a significantly decreased risk of children being overweight or obese. This relationship remained after controlling for age, area disadvantage, physical activity, time spent sedentary, weekly takeaway consumption, and the presence of FF outlets. These findings highlight the importance of the built environment as a potential contributor towards child health, which should be considered when developing community health promotion programs. Furthermore, policies related to zoning and food licensing should be considered to increase the number and range of food outlets selling healthy options in the Perth metropolitan area.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

Several studies examine the relationship between childhood obesity and fast food outlet location. However, most have not considered the impact of healthy food access on childhood obesity.

What does this article add?

This study is one of the first to show reduced levels of obesity in children living close to healthy food outlets and contributes to the debate whether access and availability to food outlets is associated with childhood weight, in a new setting: Perth, Western Australia. This study uses precise Geographical Information Systems methods to analyze a wide range of measures of food outlet accessibility and availability, while controlling for important individual-level predictors of obesity.

What are the implications for health promotion practice or research?

Our findings highlight the importance of the built environment as a potential contributor towards child health that should be considered when developing community health promotion programs.

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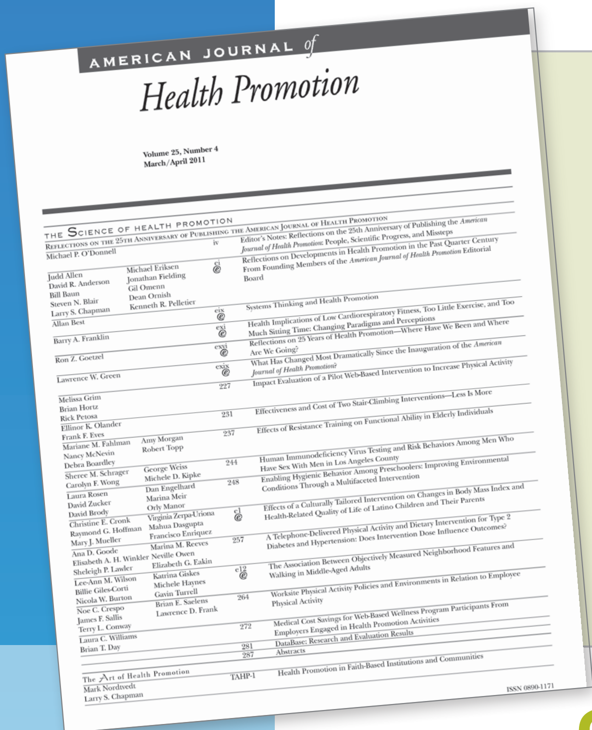

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