

Changes in neighbourhood food store environment, food behaviour and body mass index, 1981–1990

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Abstract

Objective: This paper examines trends in the neighbourhood food store environment (defined by the number and geographic density of food stores of each type in a neighbourhood), and in food consumption behaviour and overweight risk of 5779 men and women.

Design: The study used data gathered by the Stanford Heart Disease Prevention Program in four cross-sectional surveys conducted from 1981 to 1990.

Setting: Four mid-sized cities in agricultural regions of California.

Subjects: In total, 3154 women and 2625 men, aged 25–74 years.

Results: From 1981 to 1990, there were large increases in the number and density of neighbourhood stores selling sweets, pizza stores, small grocery stores and fast-food restaurants. During this period, the percentage of women and men who adopted healthy food behaviours increased but so did the percentage who adopted less healthy food behaviours. The percentage who were obese increased by 28% in women and 24% in men.

Conclusion: Findings point to increases in neighbourhood food stores that generally offer mostly unhealthy foods, and also to the importance of examining other food pattern changes that may have a substantial impact on obesity, such as large increases in portion sizes during the 1980s.

Keywords

Trends

Neighbourhood environment

Retail food stores

Fast food

Over the past decade in the USA, where obesity has reached epidemic proportions^{1,2}, there has been increasing interest in the role of the neighbourhood environment in influencing dietary behaviour. Neighbourhood socio-economic and racial composition characteristics have been observed to be associated with the location of type of food stores^{3,4} and access to fresh produce⁵, as well as diet-related health conditions such as coronary heart disease and obesity^{6–8}. Location of type of food stores may influence the types of food readily accessible. For example, chain supermarkets invariably carry fresh produce and meats while independent small corner markets and chain convenience stores tend to carry less healthy processed foods^{9,10}.

Reports of Americans not having access to healthy foods because they live in neighbourhoods where there are few or no food stores that sell affordable fresh produce^{4–7} have raised questions about social inequities with regard to the promotion of nutrition and health. The lack of neighbourhood accessibility to healthy foods particularly affects low-income residents, who may be limited by

transportation and financial constraints in their ability to obtain fresh produce and healthy foods¹¹. In the USA, most of the studies that have documented a lack of access to fresh produce have related to residents of inner-city neighbourhoods; many of these neighbourhoods have lost chain supermarkets that moved to suburban areas. Over the past two to three decades, small corner markets and chain convenience stores established themselves in these low-income neighbourhoods^{12,13}. Further, fast-food restaurants began to mark the American landscape. These changes in the distribution of retail food stores and accessibility of fast-food restaurants paralleled rapid increases in processed food production and fast-food expenditures in the USA. Between 1972 and 1992, total processed food production increased by 40%¹⁴ while fast-food expenditures increased by more than 130%¹⁵.

Processed and fast foods have been implicated in the obesity epidemic. These foods are generally higher in energy density than traditional foods prepared from fresh ingredients¹⁶, and energy-dense diets have been shown to undermine normal appetite regulation processes in

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humans¹⁷. Processed and fast foods tend to also be high in fat, salt and/or sugar and low in fibre. In addition, fast food is often consumed with highly sweetened beverages and served in large portions^{16,18,19}.

Clearly, on a national level in the USA, the neighbourhood food store environment has been changing. However, it is not clear whether changes in the neighbourhood food store environment have been experienced in all regions in the country, and mirror trends in food consumption behaviour or body mass index (BMI; kg m^{-2}), an established indicator of obesity risk. In particular, while there have been reports on the exodus of supermarkets from lower-income inner-city neighbourhoods starting in the 1960s¹³, there are few studies on secular changes in the neighbourhood food store environment in less urban areas.

The present paper uses data gathered from 5779 men and women who resided in four mid-sized cities in agricultural regions of California to describe trends in the neighbourhood food store environment (defined by the number and geographic density of food stores of each type in a neighbourhood), as well as food consumption behaviour and overweight risk.

Methods

Data sources

The study used: (1) individual-level food behaviour and sociodemographic data gathered from 3154 women and 2625 men, aged 25–74 years, who had participated in one of four cross-sectional surveys carried out between 1981 and 1990 in four mid-sized cities in California, conducted by the Stanford Heart Disease Prevention Program (SHDPP)^{20–22} and (2) neighbourhood-level food store data obtained from government and commercial sources to describe physical characteristics of the neighbourhood at the time the surveys were conducted. The research protocols were approved by the ethics committees at Stanford University School of Medicine and/or the University of California at Berkeley, and conformed to the principles of the Declaration of Helsinki.

Individual-level data

The SHDPP conducted five cross-sectional surveys from 1979 to 1990 to evaluate the effectiveness of a six-year community-based cardiovascular disease risk intervention. Only data from the second to fifth surveys (1981/82, 1983/84, 1985/86 and 1989/90) were used in the present study because relevant food behaviour data were not collected in the first survey (1979/80). Persons aged 12–74 years who resided in randomly selected households in four California cities – Monterey, Salinas, Modesto and San Luis Obispo (the first two of which received the intervention) – and were English- or Spanish-speaking

were eligible to participate in the surveys^{20,22}. To avoid clustering of risk factors by household, no more than one female and/or one male was randomly selected from each household; the data were stratified by gender. The sample size for each survey averaged 1684 individuals with response rates ranging from 56% to 69%. The respondents represented a stable population who mostly had lived in their communities for a relatively long period of time: 74% for 5 years or longer and only 7% for less than 1 year¹⁹. Since few significant changes in risk factors, morbidity and mortality were found between intervention and control cities^{20–22}, data from all cities were combined for this analysis.

Survey and clinical data were collected during a two-hour examination by nurses and other research staff trained in diet assessment, height and weight measurement, and other clinical and survey procedures. Food behaviour information was obtained by assessing the eating habits and frequency of consumption of selected foods using an interviewer-administered questionnaire. The questions asked sought to determine how often or whether the respondents ate selected foods (see list in Table 1). Most of these questions determined whether the food was eaten the day before the interview. Height and weight were measured using standardised protocols. In addition, sociodemographic information (age, race/ethnicity, education, household income) was obtained by questionnaire.

A brief non-respondent questionnaire was administered with individuals who declined to participate (75% of whom responded). There were no significant differences in age, sex and BMI (all $P \geq 0.20$), and only slight differences in educational level (mean: 13 vs. 12 years of education) for respondents vs. non-respondents²⁰.

Table 1 Assessment of food behaviour

<i>List of foods assessed</i>
<i>'Healthier' foods'</i>
● Poultry or fish including casseroles and other mixed dishes
● Beef, pork, lamb or veal including casseroles and dishes such as spaghetti, tacos or stew
● Whole-grain bread or whole-grain cereal
● Cooked dried beans such as pinto, kidney or lentils, split peas, refried beans or lima beans
● Rice, corn, noodles, potatoes or tortillas
● Milk
<i>'Less healthy' foods</i>
● Any fried food like pan-fried eggs, bacon or hamburger, or deep fat-fried foods like French fries or chicken, or sautéed or stir-fried foods
● Cured meats such as ham, lunch meats, cold cuts, bacon, sausage or hot dogs
● Salted potato chips, corn chips or crackers
● Cake, pie, sweet rolls, doughnuts, ice cream or cookies
● Candy or beverages such as sodas, or fruit drinks with added sugar like lemonade, Hi-C or Kool Aid
● Foods that are already prepared (like TV dinners, pizza, frozen main courses, canned soup, etc.)

Neighbourhood-level data

Relevant data on retail food stores (including fast-food restaurants) were obtained from the California State Board of Equalization (SBOE) and telephone business directories for the years in which the SHDPP cross-sectional surveys were conducted. The SBOE is a government agency that licenses retail businesses that sell any taxable item (such as soda or beverages); its database can be expected to include small grocery stores but not vendors that exclusively carry fresh produce and meats (non-taxable items). In a methodological study, we found it necessary to supplement the SBOE database with stores listings from the telephone directories. Use of telephone directories alone can be problematic because the same store may be listed several times under different store names, store addresses may be omitted or incorrect, and stores may be listed even after they have moved or closed²³.

The food store data we obtained included store names and street addresses and dates of operation; the street addresses were geocoded into neighbourhoods, which were defined by a combination of census tracts and/or block groups. These census-defined boundaries were verified against archival neighbourhood maps and with city planners to ensure that they corresponded with actual neighbourhood boundaries. Using these definitions, a total of 82 neighbourhoods were identified in the four cities; 70 neighbourhoods had boundaries that corresponded with individual census tracts or block groups, while the remaining 12 neighbourhoods had boundaries that reflected a combination of census tracts or block groups^{24–27}.

The neighbourhood food store environment was defined by the number and geographic density of food stores of each type in a neighbourhood. The number of food stores of each type is the count in the neighbourhood and a surrounding 0.5-mile buffer zone. The geographic store density is calculated by dividing the number of stores by the area of the neighbourhood. The creation of a buffer zone allows the inclusion of stores that lie just outside neighbourhood boundaries.

The North American Industry Classification System²⁸ and the Food Marketing Institute²⁹ definitions of retail food stores were adapted to create 11 food store categories (see Table 2). Most stores were assigned to a category based on name recognition. Store names that were vague were assigned to a category after checking the business pages of the telephone directory or making inquiries with managers/owners of existing stores or long-term residents of the neighbourhood; these were mostly small independent grocery stores, which comprised about 20% of all stores.

Data analysis

Means and standard deviations or frequency distributions of relevant sociodemographic variables were derived to

Table 2 Store type definitions

1. Chain supermarkets, defined as chain self-service grocery stores generating an annual sales volume of >\$2 million
2. Medium-sized independent grocery stores, defined as independently owned grocery stores that carry a range of products generating an annual sales volume of <\$2 million
3. Specialised markets, defined as stores that sell only specific food items such as seafood or fresh produce
4. Ethnic grocery stores, defined as independently owned stores that have an ethnic name (presumed to carry ethnic foods)
5. Small grocery stores, defined as independently owned grocery stores that sell beverages, tobacco and a limited selection of convenience foods (other than ethnic stores)
6. Chain convenience stores, defined as self-service grocery stores offering a limited line of high-convenience items, open long hours and providing easy access
7. Fast-food restaurants, defined as those nationally recognised chains that sell inexpensive, quickly served foods such as hamburgers and fried chicken
8. Pizza stores, defined as stores that primarily sell pizza
9. Pastry and other sweets: stores that primarily sell cakes, pies, ice cream, candy and other sweets
10. Bakeries: stores that primarily sell bread and rolls including croissants and muffins
11. Doughnut shops: stores that almost exclusively sell doughnuts

provide summary descriptive characteristics of the participants and the neighbourhoods in which they lived.

To examine trends in the food store environment, the mean neighbourhood store count and store density were computed for each store type in each survey year. Medium-sized independent grocery stores were omitted from the analysis, because only 1% of SHDPP participants lived in neighbourhoods with a medium-sized independent grocery store.

To examine trends in food behaviour, the percentage of participants consuming a list of selected foods for each survey year was calculated; these foods were then categorised as 'healthier foods' or 'less healthy foods'. Specifically, foods that were generally high in fat, sugar or salt were considered less healthy foods – fried foods, cured meats, salted chips, cake/pie, candy and other sweets ('sweets') and TV dinners or pre-prepared foods – while fresh meat including poultry, whole-grain fibre, rice/corn/noodles, beans and milk were considered healthier foods. All categorical variables (expressed as percentages) were examined for trend using the Cochran–Armitage trend test, while continuous variables were examined for trend using a Poisson regression model with survey as the time effect.

Results

Across all four surveys, participants had a mean age of 45 years and were primarily non-Hispanic White (83%) and married (68%) (Table 3). Approximately 60% had more than 12 years of education, and 43% had household incomes that were greater than 400% of the Federal Poverty Level³⁰.

Table 3 Sociodemographic profile of study participants, aged 25–74 years (1981–1990)*

Characteristic	1981/82 (n = 724)	1983/84 (n = 1738)	1985/86 (n = 1652)	1989/1990 (n = 1665)	Total (n = 5779)
Age (years), mean ± SD	44.9 ± 14.8	45.1 ± 14.0	44.8 ± 13.7	44.2 ± 13.9	44.7 ± 14.0
Ethnicity (%)					
White, non Hispanic	83.0	81.6	90.4	77.5	83.1
Hispanic	11.3	10.1	9.6	14.4	11.4
Other	5.7	8.3	0.0	8.1	5.5
Marital status					
% married	68.1	70.2	68.0	64.5	67.7
Education (%)					
<12 years	15.2	15.7	12.6	13.8	14.2
12 years	31.4	25.3	26.4	25.2	26.3
>12 years	53.4	59.0	61.0	61.0	59.5
Household income/poverty threshold					
0–200%	25.5	21.7	19.4	20.2	20.8
201–400%	39.0	27.6	38.2	32.4	36.0
401–600%	19.9	28.5	21.3	26.8	23.3
>600%	15.5	22.2	21.1	20.6	19.9

SD – standard deviation.

*Data gathered in four cross-sectional surveys conducted from 1981 to 1990. Sample includes one woman per household and/or one man per household.

Table 4 Neighbourhood characteristics over time by city, 1980 and 1990 Census

	Monterey	Salinas	Modesto	San Luis Obispo	Total
Number of neighbourhoods	22	20	33	7	82
	Neighbourhood	Neighbourhood	Neighbourhood	Neighbourhood	Neighbourhood
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Square miles	0.6 ± 0.4	1.8 ± 2.9	1.2 ± 0.8	29.9 ± 44.2	3.6 ± 14.6
<i>1980 Census</i>					
Population	373 ± 223	505 ± 257	291 ± 269	541 ± 403	363 ± 277
Median household income (\$)	15 607 ± 3685	17 068 ± 3919	17 475 ± 5715	15 952 ± 4482	16 120 ± 4701
% with <12 years' education	19.3 ± 8.6	34.0 ± 18.5	35.8 ± 19.1	12.8 ± 5.5	27.7 ± 18.7
% unemployed	6.0 ± 3.2	10.1 ± 4.3	12.7 ± 9.0	5.4 ± 2.1	8.6 ± 7.5
% Hispanic	6.8 ± 4.0	27.0 ± 20.5	11.0 ± 12.8	6.4 ± 2.0	10.0 ± 17.2
<i>1990 Census</i>					
Population	2432 ± 1704	4650 ± 2941	4874 ± 2073	7383 ± 2743	4250 ± 2584
Median household income (\$)	32 287 ± 6615	31 951 ± 8314	29 090 ± 8470	29 931 ± 10 455	30 167 ± 8190
% with <12 years' education	14.9 ± 10.2	27.3 ± 20.6	34.7 ± 17.6	10.3 ± 3.1	23.1 ± 18.7
% unemployed	4.4 ± 2.8	7.6 ± 6.1	9.9 ± 8.7	4.8 ± 3.7	6.8 ± 7.3
% Hispanic	8.8 ± 8.6	35.9 ± 25.7	14.2 ± 15.1	8.2 ± 2.9	13.3 ± 21.2

SD – standard deviation.

Socio-economic characteristics of the neighbourhoods for each of the four cities for the years 1980 and 1990 (when the US Census was conducted) are shown in Table 4. From 1980 to 1990, the populations of all four cities grew more than 10-fold from 363 000 to 4.3 million; median household income increased by 87% from \$16 000 to \$30 000; the percentage with less than 12 years of education decreased from 28% to 23%; and the percentage unemployed dropped from 8.6% to 6.8%. The Hispanic population in all four cities also increased from 10% of the total population to 13%.

Changes in neighbourhood food store environment from 1981 to 1990 are shown in Table 5. In terms of both neighbourhood count of stores and store density, stores selling sweets, pizza stores, small grocery stores and fast-food restaurants showed large increases from 1981 to

1990. For example, the mean count per neighbourhood and density of stores that sold pastries and other sweets increased by 180% and 152%, respectively. Chain supermarkets and chain convenience stores showed more modest increases.

Changes in individual food behaviour over the period 1981–1990 are indicated by the percentage of participants who consumed selected foods the day previous to the interview. There were notable increases among both men and women in the percentage consuming what are generally considered 'healthy' foods. The percentage reporting consumption of poultry/fish, cooked dried beans and reduced-fat milk increased by 12–26% in men and 13–20% in women. However, over the same period, while there were significant decreases in the percentage reporting consumption of fried foods (men: 20%

Table 5 Neighbourhood food store patterns, 1981–1990

	Survey year				% change 1981/82–1989/90	Test for trend <i>P</i> -value
	1981/82	1983/84	1985/86	1989/90		
Mean no. of stores in neighbourhood						
Supermarkets	26	23	29	31	+19.2	0.71
Specialised markets	10	15	12	18	+80.0	0.44
Ethnic grocery stores	18	13	17	23	+27.8	0.41
Small grocery stores	42	48	51	63	+50.0	0.21
Convenience stores	52	60	63	63	+21.2	0.71
Fast-food restaurants	53	55	68	87	+64.2	0.01
Pizza stores	45	56	69	86	+91.1	0.002
Stores selling sweets*	10	9	16	28	+180.0	0.004
Bakeriest†	7	5	8	7	0.0	0.86
Doughnut shops	20	20	25	29	+45.0	0.50
Total	280	304	358	435	+55.3	<0.001
Density (no. of stores/sq. mile)‡						
Supermarkets	1.2	1.2	1.3	1.3	+5.6	0.19
Specialised markets	0.9	1.4	1.2	1.1	+16.0	0.28
Ethnic grocery stores	1.5	1.0	1.2	1.4	−2.9	0.01
Small grocery stores	2.5	3.2	3.4	4.1	+60.3	<0.001
Convenience stores	3.1	3.7	3.9	3.6	+17.6	<0.001
Fast-food restaurants	2.7	2.9	3.3	4.2	+53.7	<0.001
Pizza stores	2.4	2.9	3.4	4.5	+85.2	<0.001
Stores selling sweets*	0.5	0.8	1.0	1.3	+152.1	<0.001
Bakeriest†	0.5	0.3	0.6	0.4	−21.7	0.94
Doughnut shops	1.0	1.0	1.2	1.2	+24.7	0.004

*Including ice-cream, candy, cake and pie.

†Primarily sells bread, muffins, croissants and/or bagels.

‡Includes 0.5-mile buffer zone.

Table 6 Individual dietary habits and BMI over time: men aged 25–74 years

	Survey year				% change 1981/82–1989/90	Test for trend <i>P</i> -value
	1981/82 (<i>n</i> = 322)	1983/84 (<i>n</i> = 804)	1985/86 (<i>n</i> = 747)	1989/90 (<i>n</i> = 752)		
% consuming each type of food						
Healthier foods						
Poultry/fish yesterday	42.5	42.7	44.2	47.7	+12.2	0.04
Meat dishes yesterday	75.8	77.4	72.3	67.4	−11.1	<0.001
Whole-grain bread/cereal yesterday	54.4	53.2	57.2	56.4	+3.7	0.22
Cooked dried beans yesterday	22.1	21.3	22.2	26.0	+17.6	0.05
Rice, corn, noodles yesterday	67.8	67.8	66.4	71.4	+5.3	0.19
Milk (any type)	91.3	88.4	93.8	89.9	−1.5	0.56
Milk (non-fat or low-fat)	55.8	56.5	64.4	70.4	+26.2	<0.001
Eggs (≥1/week)	88.8	87.8	82.1	71.3	−19.7	<0.001
Less healthy foods						
Fried foods yesterday	54.7	56.0	48.5	43.9	−19.7	<0.001
Cured meat yesterday	45.7	42.5	37.5	35.4	−22.5	<0.001
Salted chips yesterday	30.2	29.8	25.3	29.2	−3.3	0.46
Cake/pie yesterday	51.6	57.3	56.8	57.3	+11.0	0.23
Sweets yesterday	38.8	44.7	44.6	52.5	+35.3	<0.001
TV dinners or other prepared foods	81.0	84.8	86.5	84.6	+4.4	0.22
% overweight*						
% obese†	58.6	59.0	62.3	62.7	+7.0	0.08
BMI (kg m ^{−2})	14.1	14.8	15.8	17.5	+24.1	0.09
Physical activity‡	26.2	26.3	26.6	26.6	+1.5	0.05
Physical activity‡	4.8	4.5	4.7	4.8	0.0	0.12

BMI – body mass index.

*BMI = 25.0–29.99 kg m^{−2}.†BMI ≥ 30.0 kg m^{−2}.

‡Physical activity was rated using a 1–7 scale with 7 being the most active.

decrease, women: 32% decrease) and cured meats (men: 23% decrease, women: 16% decrease), the percentage reporting consumption of other less healthy foods increased: sweets by 35% in men and 15% in women, and

TV dinners and other pre-prepared foods by 4–5% among both men and women (Tables 6 and 7).

Changes in BMI over 1981–1990 reflected nationwide trends, with mean BMI increasing by 1.5% in men

Table 7 Individual dietary habits and BMI over time: women aged 25–74 years

	Survey year				% change 1981/82–1989/90	Test for trend <i>P</i> -value
	1981/82 (<i>n</i> = 402)	1983/84 (<i>n</i> = 934)	1985/86 (<i>n</i> = 905)	1989/90 (<i>n</i> = 913)		
% consuming each type of food						
Healthier foods						
Poultry/fish yesterday	42.5	43.4	43.8	50.4	+18.6	0.002
Meat dishes yesterday	68.7	65.1	62.5	54.7	−20.4	<0.001
Whole-grain bread/cereal yesterday	51.5	56.7	57.9	56.4	+9.5	0.20
Cooked dried beans yesterday	22.7	17.9	20.2	25.6	+12.8	0.01
Rice, corn, noodles yesterday	69.8	69.0	66.9	69.1	−1.0	0.73
Milk (any type)	91.3	88.4	92.2	92.0	+0.8	0.07
Milk (non-fat or low-fat)	62.6	62.7	69.6	75.4	+20.4	<0.001
Eggs (≥1/week)	83.3	82.2	77.1	66.2	−20.5	<0.001
Less healthy foods						
Fried foods yesterday	47.9	47.8	43.3	32.5	−32.2	<0.001
Cured meat yesterday	32.1	31.9	29.8	26.9	−16.2	0.02
Salted chips yesterday	22.2	24.4	22.5	23.9	+7.7	0.84
Cake/pie yesterday	55.0	53.9	54.3	49.8	−9.5	0.06
Sweets yesterday	37.1	37.9	37.2	42.5	+14.6	0.04
TV dinners or other prepared foods	82.0	82.1	83.0	85.8	+4.6	0.03
% overweight*	41.0	40.4	42.2	46.3	+12.9	0.02
% obese†	16.3	16.9	15.8	20.9	+28.2	0.03
BMI (kg m ^{−2})	25.3	25.4	25.2	26.1	+3.2	0.01
Physical activity‡	4.4	4.1	4.3	4.4	0.0	0.21

BMI – body mass index.

* BMI = 25.0–29.99 kg m^{−2}.

† BMI ≥ 30.0 kg m^{−2}.

‡ Physical activity was rated using a 1–7 scale with 7 being the most active.

and 3.2% in women, and the percentage of men and women who were obese (BMI ≥ 30.0 kg m^{−2}) increasing rapidly, from 14.1% to 17.5% in men and from 16.3% to 20.9% in women (Tables 6 and 7).

Discussion

This analysis of data from four mid-sized cities in California found increases in the number and density of all types of stores, except bakeries. The stores that showed the greatest increases in absolute counts per neighbourhood, and also statistically significant increasing trends, were stores that sold sweets, pizza stores and fast-food restaurants. The stores that showed the greatest increases in density were stores selling sweets, pizza stores, small grocery stores, fast-food restaurants, doughnut shops and convenience stores.

Changes in individual food behaviour were not entirely consistent with these trends. The increases in the number and/or density of stores that sold sweets, doughnut shops, small grocery stores and convenience stores paralleled increases in the percentage of participants reporting consumption of sweets and TV dinners and other pre-prepared foods. However, increases in fast-food restaurants did not correspond with an increase in the percentage of participants reporting consumption of fried foods (defined to include hamburgers), which actually

showed a decrease of 32% for women and 20% for men, from 1981 to 1990. The percentage of participants who consumed healthier choices of selected protein foods (poultry/fish, cooked dried beans, reduced-fat milk) increased by 12–26%. However, the percentage who consumed less healthy foods also increased: sweet foods by 15% in women and 35% in men, and TV dinners and other pre-prepared foods by about 4% in both women and men. During the same period, the percentage of participants who were overweight increased significantly by 13% for women and 7% for men. Obesity prevalences increased more rapidly, by 28% for women and 24% for men.

These observations of individual dietary behaviour and overweight risk are consistent with findings from national surveys. Using data from the 1965 Nationwide Food Consumption Survey and the 1994–1996 Continuing Survey of Food Intake of Individuals, Popkin *et al.* found that diet quality, with the exception of calcium intake, had improved across racial/ethnic groups and socio-economic groups. However, they noted that despite the increase in diet quality, the average energy intake of Americans has also increased³¹. The increase in the percentage of SHDPP participants consuming sweets and TV dinners and pre-prepared foods is consistent with the increase in energy intake observed in the general US population. Similarly, the increases in the percentage consuming healthier choices of protein

foods (poultry/fish, cooked dried beans, reduced-fat milk) and the decrease in the percentage consuming fried foods are consistent with the finding of improved diet quality.

There are several limitations to this study. The assessment of food behaviour used by the SHDPP did not include fruits and vegetables, which at the time (1980s) were not the primary focus of most nutrition interventions³². Fast-food items were not asked about specifically; instead, they were classified as fried foods together with non-fast-food fried items. Further, the assessment of consumption of selected foods did not seek information on portion size. It is likely, for example, that while the percentage of individuals consuming fried foods decreased, the average portion size among consumers increased over time³³.

Store data were archival so it was not possible to physically observe the types of foods carried by the stores at the time of the surveys. Further, categorisation of the stores was based on name recognition, and made with the help of current store owners/managers and long-term residents. There is likely to be error in categorisation of the stores, especially older stores that no longer existed at the time of this study.

The analysis was limited to data gathered from adults only, and the apparent inconsistency between the increasing trend of fast-food restaurants and the decreasing percentage of SHDPP participants consuming fried foods may reflect differences in preference for fast food between adults and children. Finally, the cross-sectional nature of the survey data prevented the use of more rigorous analytical techniques to prospectively examine changes in individual-level behaviour in relation to changes in the neighbourhood food store environment over time.

In conclusion, this study has documented increases in all types of food stores, with the exception of bakeries, in four mid-sized cities in agricultural regions of California; stores that usually carry less healthy foods (stores selling sweets, pizza stores, small grocery stores, fast-food restaurants, doughnut shops and convenience stores) showed the greatest increases. This observation echoes the trends observed in more urban regions. Many efforts are being made throughout the nation to address obesity by intervening at the environmental level. For example, in California, the California Endowment established the Healthy Eating, Active Communities Initiative, a \$26 million four-year initiative, to improve the food and physical activity environments of school-aged children³⁴. Findings from evaluation studies of such environmentally focused programmes will direct future research and intervention efforts. Meanwhile, it is important to conduct more definitive studies to delineate the role of the environment in determining food behaviour. While the types of retail food stores in a neighbourhood clearly affect the availability and accessibility of various types of foods⁹, other

factors such as knowledge, social and cultural norms and values, and financial resources (including ownership of a vehicle) also determine food purchasing and consumption behaviour in the USA^{7,11}. The weight of these factors in their influences on individuals and families will shape the design of effective interventions.

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Authors' contributions: M.C.W. conceived of and led the study, and drafted the manuscript. C.C. assisted with the data management, analysis and interpretation, and with drafting the manuscript. D.A. advised on the use of appropriate statistical methods, performed the statistical analysis, and assisted with data interpretation. M.A.W. provided guidance on the study design, and data analysis and interpretation, and contributed to the manuscript. All authors read and approved the final manuscript.

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References

- 1 Flegal KM. The obesity epidemic in children and adults: current evidence and research issues. *Medicine and Science in Sports and Exercise* 1999; **31**(11 Suppl.): S509–14.
- 2 Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *JAMA: Journal of the American Medical Association* 2004; **291**: 2847–50.
- 3 Morland K, Wing S, Diez-Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine* 2002; **22**: 23–9.
- 4 Zenk SN, Schulz AJ, Israel BA, James SA, Bao S, Wilson ML. Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health* 2005; **95**: 660–7.
- 5 Zenk SN, Schulz AJ, Israel BA, James SA, Bao S, Wilson ML. Fruit and vegetable access differs by community racial composition and socioeconomic position in Detroit, Michigan. *Ethnicity & Disease* 2006; **16**: 275–80.
- 6 Morland K, Diez Roux AV, Wing S. Supermarkets, other food stores, and obesity: the Atherosclerosis Risk in Communities study. *American Journal of Preventive Medicine* 2006; **30**: 333–9.
- 7 Wang MC, Kim S, Gonzalez AA, MacLeod KE, Winkleby MA. Socioeconomic and food-related physical characteristics of the neighborhood environment are associated with body mass index. *Journal of Epidemiology and Community Health* 2007; **61**: 491–8.

- 8 Diez-Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, *et al.* Neighborhood of residence and incidence of coronary heart disease. *New England Journal of Medicine* 2001; **345**: 99–106.
- 9 Sloane DC, Diamant AL, Lewis LB, Yancey AK, Flynn G, Nascimento LM, *et al.*; REACH Coalition of the African American building a Legacy of Health Project. Improving the nutritional resource environment for healthy living through community-based participatory research. *Journal of General Internal Medicine* 2003; **18**: 568–75.
- 10 Block D, Kouba J. A comparison of the availability and affordability of a market basket in two communities in the Chicago area. *Public Health Nutrition* 2006; **9**: 837–45.
- 11 United States Department of Agriculture. *Food Stamp Participants' Access to Food Retailers: Summary of Findings, 1999* [online]. Available at <http://www.fns.usda.gov/oane/MENU/Published/nutritioneducation/Files/sumnfsps2.htm>. Accessed 15 June 2007.
- 12 Kolodinsky J, Cranwell M. The poor pay more? Now they don't even have a store to choose from: Bringing a Supermarket Back to the City. *Consumer Interests Annual* 2000; **46**: 101–6.
- 13 Pothukuchi K. Attracting supermarkets to inner-city neighborhoods: economic development outside the box. *Economic Development Quarterly* 2005; **19**: 232–44.
- 14 Schluter G, Lee C. Changing food consumption patterns: their effect on the US food system, 1972–1992. *Food Reviews International* 1999; **22**: 35–7.
- 15 Jekanowski MA. Causes and consequences of fast food sales growth. *Food Reviews International* 1999; **22**: 11–16.
- 16 Prentice AM, Jebb SA. Fast foods, energy density and obesity: a possible mechanistic link. *Obesity Reviews* 2003; **4**: 187–94.
- 17 Prentice AM, Poppitt SD. Importance of energy density and macronutrients in the regulation of energy intake. *International Journal of Obesity and Related Metabolic Disorders* 1996; **20**(Suppl. 2): S18–23.
- 18 Raben A, Vasilaras TH, Moller AC, Astrup A. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 weeks of supplementation in overweight subjects. *American Journal of Clinical Nutrition* 2002; **76**: 721–9.
- 19 Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes 1977–1998. *JAMA: Journal of the American Medical Association* 2003; **289**: 450–3.
- 20 Farquhar JW, Fortmann SP, Flora JA, Taylor CB, Haskell WL, Williams PT, *et al.* Effects of communitywide education on cardiovascular disease risk factors: The Stanford Five-City Project. *JAMA: Journal of the American Medical Association* 1990; **264**: 359–65.
- 21 Winkleby MA, Feldman HA, Murray DM. Joint analysis of three US community intervention trials for reduction of cardiovascular disease risk. *Journal of Clinical Epidemiology* 1997; **50**: 645–58.
- 22 Fortmann SP, Varady AN. Effects of a community-wide health education program on cardiovascular disease morbidity and mortality: The Stanford Five-City Project. *American Journal of Epidemiology* 2000; **152**: 316–23.
- 23 Wang MC, Gonzalez AA, Ritchie LD, Winkleby MA. The neighborhood food environment: sources of historical data on retail food stores. *International Journal of Behavioral Nutrition and Physical Activity* 2006; **3**: 15.
- 24 Pollack CE, Cubbin C, Ahn D, Winkleby M. Neighbourhood deprivation and alcohol consumption: does the availability of alcohol play a role? *International Journal of Epidemiology* 2005; **34**: 772–80.
- 25 Cubbin C, Winkleby MA. Protective and harmful effects of neighborhood-level deprivation on individual-level health knowledge, behavior changes, and risk of coronary heart disease. *American Journal of Epidemiology* 2005; **162**: 559–68.
- 26 Chuang YC, Cubbin C, Ahn D, Winkleby MA. Effects of neighbourhood socioeconomic status and convenience store concentration on individual level smoking. *Journal of Epidemiology and Community Health* 2005; **59**: 568–73.
- 27 Winkleby M, Cubbin C, Ahn D. Effect of cross-level interaction between individual and neighborhood socioeconomic status on adult mortality rates. *American Journal of Public Health* 2006; **96**: 2145–53.
- 28 US Census Bureau. *North American Industry Classification System, Revisions for 2002* [online]. Available at <http://www.census.gov/epcd/naics02/naicod02.htm#N44>. Accessed 16 August 2007.
- 29 Food Marketing Institute. *Language of the Food Industry Glossary of Supermarket Terms* [online]. Available at http://www.fmc.org/facts_figs/glossary_search.cfm. Accessed 3 September 2007.
- 30 US Census Bureau. *Poverty: Definitions* [online]. Available at <http://www.census.gov/hhes/www/poverty/definitions.html>. Accessed 16 August 2007.
- 31 Popkin BM, Zizza C, Siega-Riz AM. Who is leading the change? US dietary quality comparison between 1965 and 1996. *American Journal of Preventive Medicine* 2003; **25**: 1–8.
- 32 US Department of Agriculture. *Nutrition and Your Health: Dietary Guidelines for Americans*, 2d ed. Home and Garden Bulletin No. 232. Washington, DC: US Government Printing Office, August 1985.
- 33 Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *American Journal of Public Health* 2002; **92**: 246–9.
- 34 The California Endowment. *The Healthy Eating, Active Communities' Initiative* [online]. Available at http://www.calendow.org/news/press_releases/2005/03/HEACFactSheet.pdf. Accessed 16 December 2006.