

Education moderates the association between supermarket environment and diet

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Key words: supermarkets; dietary inequalities; food environment; dietary quality; maternal health.

Abstract

Introduction: Supermarkets are a major source of food for many families. Knowledge of how educational attainment affects the relationship between the in-store environments of supermarkets and diet is needed. This study examined the relationship between maternal dietary quality and overall in-store supermarket environment, and assessed the effect modification of educational attainment.

Methods: Dietary quality z-scores were calculated for 829 mothers with young children using cross-sectional data collected in 2010-2011 from a 20-item food frequency questionnaire. Information about nine in-store factors (variety, price, quality, promotion, shelf placement, store placement, nutrition information, healthier alternatives and single fruit sale) on 12 foods known to discriminate between better and poorer dietary quality were collected from supermarkets and used to create a standardised 'healthfulness' z-score for each supermarket where mothers shopped.

Results: Multi-level unadjusted linear regression analysis completed in 2014-2015 showed that shopping at more healthful supermarkets was associated with better dietary quality ($\beta=0.39$ SD/SD; $p=0.01$; 95%CI: 0.10, 0.68). However, the relationship differed according to level of educational attainment (interaction $p=0.006$). Among mothers who left school at 16 years of age, those who shopped at less healthful supermarkets had poorer dietary quality ($\beta=0.31$ SD/SD; 95%CI: 0.07, 0.55). Among mothers with degrees, those who shopped at less healthful supermarkets had better dietary quality ($\beta=-0.59$ SD/SD; 95%CI: -1.19, 0.00).

Conclusions: Mothers with low educational attainment showed greater susceptibility to less healthful in-store environments than mothers with higher educational attainment who may be protected by greater psychological and financial resources. Policy initiatives to improve supermarket environments may be necessary to address dietary inequalities.

Introduction

Supermarkets are a major source of food for many families.¹ Supermarkets account for 87% of grocery sales in the United Kingdom (UK)² and \$630 billion of sales annually in the United States (US).³ Consumers' food choices within supermarkets can be influenced by a range of in-store environmental factors including the price, promotion, placement, variety and quality of products.⁴

Government policy has placed increasing emphasis on changing dietary behaviours through initiatives at the environmental level by 'nudging' people to make healthier choices.⁵ The premise of 'nudging' is that much human behaviour is automatic, cued by environmental stimuli and largely unaccompanied by conscious reflection.⁶ It has been suggested that supermarkets offer a non-neutral environment which largely directs the food choices of an almost captive market in favour of energy-dense processed products with the greatest profit margin, which makes them an important site for intervention to improve dietary behaviours.⁷ Empirical understanding of how environmental factors within supermarkets influence diet is limited,^{8,9} and even less is known about how educational attainment, a major determinant of dietary behaviour,^{10,11} affects this relationship.

Systematic reviews examining the environmental determinants of diet reveal that research has focused on the effects of neighbourhood access to food outlets, food price and availability of healthy food.^{9,12} While there is evidence from the US that greater availability and cheaper pricing of healthy food is associated with healthier diets, evidence from other high-income countries is equivocal and limitations of the literature exist.^{8,12} Few studies have measured environmental factors within stores people use¹³ or measured multiple aspects of the in-store environment to capture the combined effects of in-store marketing strategies.¹⁴

There is widespread recognition of the importance of maternal nutrition to optimise childhood development, and the need to create environments that cue mothers, particularly those from disadvantaged backgrounds, to make healthy food choices.^{15, 16} Investigating the educational pathways between the in-store environments of supermarkets where mothers shop and their diet could improve the evidence base for interventions to reduce dietary inequalities. This study aimed to assess i) whether the overall in-store environment of the supermarket used most often for food shopping was associated with dietary quality among a population-based sample of mothers and ii) whether level of educational attainment moderated this relationship.

Methods

Study sample

Participants were mothers with young children taking part in the Southampton Initiative for Health¹⁷ follow-up survey, conducted between December 2010 and May 2011 in Hampshire, UK. A cross-sectional sample of 921 mothers or pregnant women completed a questionnaire either by telephone or face to face: 509 mothers were part of the cohort and an additional 412 were recruited, which enhanced representation of mothers with lower educational attainment. All mothers were recruited whilst attending Sure Start Children's Centres.¹⁸ Mothers were asked questions about their age, number of children, highest educational qualification attained, employment status and home postcode, and nominated the supermarket where they did most of their food shopping (main supermarket). Home postcode was used to determine mothers' level of neighbourhood deprivation according to quintiles of the 2007 English Index of Deprivation income domain.¹⁹ A 20-item food frequency questionnaire (FFQ) was used to

assess dietary quality.²⁰ Study procedures were approved by the Southampton and South West Hampshire Local Research Ethics Committee.

Outcome measure

The 20 item FFQ was derived from a 100-item FFQ and contained foods that represent the UK Department of Health's dietary recommendations and foods known to contribute to noncommunicable diseases.^{10, 20} Mothers were asked to indicate how often in the previous month they consumed each of the 20 foods (six point scale from 'never' to 'once or more than once a day'). A dietary quality score was calculated for each mother by multiplying her consumption frequency for each item by corresponding coefficients identified from a principal components analysis and then summing the results.²⁰ The dietary scores were standardised to have a mean of zero and standard deviation (SD) of one. Diet scores calculated from this 20-item FFQ have correlated highly with scores from the 100-item FFQ ($r=0.94$), and with red blood cell folate ($r=0.25$).²⁰ Higher scores represented better dietary quality and characterised higher intakes of vegetables (e.g. peppers, tomatoes, lettuce) and wholegrain bread and lower intakes of processed meats (e.g. sausages), crisps and sugar.

Exposure measure

In August 2010 the names and postcodes of all grocery stores and supermarkets within six local councils (Southampton, Eastleigh, Fareham, Gosport, Havant and Portsmouth) in Hampshire, UK were identified using Food Safety Registers and online service directories (yellow-pages and yell.com). These areas were selected because participating mothers lived and shopped here. Stores were classified into seven categories (premium supermarkets, large supermarkets, discount supermarkets, small supermarkets, 'world' stores, convenience stores, petrol stores) based on previous research in northern England.²¹ Due to regional differences,

some categories were informed by the Local Authority Enforcement Monitoring System.²² From July 2010 to June 2011 trained workers ‘ground-truthed’ the study area to confirm store existence and location, identify additional stores and survey the in-store environment using a published tool.²³ Information on the *number of varieties, price, promotion, shelf placement* and *store placement* were collected about seven healthy (peppers, tomatoes, lettuce, onions, apples, bananas, wholemeal bread) and five less healthy products (oven chips, sausages, crisps, sugar, white bread). Data about the type of *nutrition information* and availability of *healthier alternatives* were also collected for the less healthy products. The *quality* of two fruits and four vegetables, and whether or not the fruits could be *bought singly* were also measured. These nine in-store factors were assessed because they can affect consumers’ food choices.⁴ The twelve food products were selected because they represent items from FFQs used to discriminate between better and poorer dietary patterns.^{20, 24, 25}

Based on these data a composite score representing the healthfulness of the in-store supermarket environment was created for each store using published methods.²³ Z-scores for each of the nine in-store variables were created by subtracting the summed ratings for unhealthy products from the summed ratings for healthy products and standardising the result. The z-scores for the nine variables were then summed and divided by nine. This standardisation and division ensured each in-store variable was equally weighted. Scores across the sample of 601 grocery stores and supermarkets were standardised to have a mean of zero and SD of one, and ranged from -1.86 to 2.15. One SD difference in healthfulness score is equivalent to a more healthful store having eleven more varieties of healthy foods, double the number of healthier alternatives of less healthy food products and a cheaper mean price (£/portion) of the healthy than the less healthy foods (up to 31 pence). Data from mothers’ nominated main supermarkets were linked to their individual data. Median values of

supermarket healthfulness have been reported because after linking the supermarket data to mothers' individual data the distribution of healthfulness scores became negatively skewed. These exposure measures were not normalised because they reflect the true variation in the environments mothers were exposed to.

Statistical analyses

Differences in mothers' dietary quality score, age, number of children and employment status according to their level of educational attainment (low: \leq General Certificate of Secondary Education (GCSE) achieved at 16 years of age), mid: Advanced Level/Higher National Diploma, and high: tertiary degree) were assessed using a linear or logistic regression test for trend. Differences in number of children and neighbourhood deprivation across the three education groups were assessed using Spearman test for trend, and differences in mothers' type of main supermarket were analysed by Fisher's Exact test.

In 2014-2015, multi-level linear regression models were used to examine the relationship between mothers' dietary quality and healthfulness score of their main supermarket. These models accounted for clustering within stores after adjusting for healthfulness score (intraclass correlation coefficient=0.08). Interaction terms for educational attainment and supermarket healthfulness were added to the regression model to assess effect modification of education. Stratified analyses were conducted to identify the strength and direction of the relationship between store healthfulness and dietary quality separately for each level of educational attainment. Adjustments were made for covariates that were independently associated with the dietary quality including age, number of children and level of neighbourhood deprivation. Employment status was also added to the regression models as a

potential confounder. Type of main supermarket was not associated with dietary quality in the adjusted regression models and was thus removed from these analyses.

Results

Sample characteristics

A total of 829 mothers identified their main supermarket within the study area. Table 1 presents key characteristics of the 818 mothers who reported their highest educational qualification and shows several differences in these characteristics by educational attainment. Over a third of mothers (37%) had no educational qualifications beyond 16 years of age (low educational attainment). These mothers were younger, had more children and lived in more deprived neighbourhoods than mothers with higher educational attainment (all $p < 0.001$). Fewer mothers with low educational attainment were in paid employment ($p = 0.01$) and more shopped at discount supermarkets than mothers with higher educational attainment, though there was no difference in median supermarket healthfulness across the three education levels. The mean dietary quality score for mothers with low educational attainment was significantly lower than mothers with higher educational attainment ($p < 0.001$). Mothers with no qualifications beyond 16 years of age had a mean dietary quality score almost 1SD lower than those with degree qualifications, equivalent to eating salad vegetables up to six times less often, and crisps up to six times more often a week. Each time is assumed to represent a standard portion size.

A total of 49 different supermarkets within the study area were used by mothers. The median score of healthfulness for these stores was 1.78SD (IQR: 1.69 to 1.94), with scores ranging from -0.75 to 2.15. Table 2 shows the median healthfulness of the four types of supermarkets.

Discount supermarkets had the lowest healthfulness score while large and premium supermarkets had the highest. There was almost 1SD difference between these median scores.

Association between store healthfulness and mothers' dietary quality

Multi-level linear regression analysis revealed a strong relationship between dietary quality and the healthfulness of main supermarket among the full sample of mothers where shopping at a more healthful store was associated with better dietary quality ($\beta=0.39$ SD/SD; 95%CI: 0.10, 0.68). The association attenuated after adjustment for confounding variables ($\beta=0.07$ SD/SD; 95%CI: -0.13, 0.26). Exploration of the adjusted model showed that the attenuation was mainly due to educational attainment.

There was a significant interaction between healthfulness of main supermarket and educational attainment ($p=0.006$), with differences observed between low and mid educational attainment levels ($\beta=-0.47$, $p=0.04$), and low and high educational attainment levels ($\beta=-0.90$, $p=0.004$). Stratified regression analyses showed: (i) a strong positive relationship between dietary quality and store healthfulness among mothers with low educational attainment; (ii) no significant association among mothers with mid educational attainment; and (iii) that poorer store healthfulness was associated with better dietary quality among mothers with high educational attainment (Table 3, Figure 1). Adjustment for covariates had little effect on the relationship among mothers with low educational attainment but weakened the relationship among mothers with high educational attainment. Among mothers with low educational attainment, each SD difference in store healthfulness was positively associated with a 0.31 SD difference in dietary quality score, which is equivalent to consuming vegetable dishes up to four times more often a week, and crisps up to four times

less often a week. This adjusted model for mothers with low educational attainment explained one fifth of the variance in dietary quality.

Discussion

To the authors' knowledge, this is the first study to assess whether the overall environment of the supermarket individuals' used to do most of their grocery shopping was associated with their dietary quality. This methodology provides a more nuanced assessment of the relationship between the in-store environment of supermarkets and dietary behaviours than previous work. The healthfulness of main supermarket was positively associated with dietary quality among the full sample of mothers with young children who participated in this study. This relationship attenuated after adjustment for confounding variables though was mainly due to the effect of educational attainment.

There was strong evidence that educational attainment moderated the relationship between dietary quality and healthfulness of main supermarket. Among mothers who had no qualifications beyond 16 years of age, shopping at less healthful stores was associated with poorer dietary quality. In contrast, there was a marginally significant trend among mothers with degrees where those who shopped at less healthful supermarkets had better dietary quality than those who used more healthful supermarkets. These findings suggest that the food choices of mothers of low educational attainment may be more heavily influenced by the environment of their main supermarket, while those with higher educational attainment show greater resilience to the influence of poorer supermarket environments.

Our study confirmed the educational gradient in diet identified in previous research.^{11, 26} The majority of mothers in this study shopped for groceries at the four major UK supermarket

chains and had average dietary quality. A smaller proportion of mothers shopped at discount supermarkets and had poorer quality diets. These findings are similar to research from northern England which found that 77% of more than 5000 participants' shopped at large supermarkets and 14% shopped at discount supermarkets; those who used discount supermarkets had lower educational attainment.²⁷

A limited number of studies have linked data about individuals' main supermarkets to their dietary data.¹² One US study involving 186 low-income women aged 40-64 years found no association between healthy food availability in their main food store and daily fruit and vegetable intake.²⁸ Another US study of 121 highly educated men and women, found that better availability, pricing and quality of healthy food products in their main food store related to lower consumption of sweetened beverages, but was not associated with consumption of fruit, vegetables, milk, meat, sweets or cereals.²⁹ The lack of consistency in findings between these studies and the current study may be explained by methodological differences. The US studies focused on the availability of healthy products, while the current study surveyed a range of healthy and less healthy products and included nine in-store environmental factors. However, the differences may be indicative of true variations.

Prior research may help to explain the mechanism behind the finding that mothers with low educational attainment had poorer quality diets if they shopped at less healthful supermarkets. Qualitative work with low-income residents in the US identified two competing levels of influence on food shopping behaviour.^{30, 31} First, limited economic resources created a need to plan for cost-effective choices that would provide enough food for their family. Second, the marketing activities within supermarkets prompted them to make unplanned purchases of less healthy products. Similar concerns about the cost of healthy foods, frequent promotion of

less healthy foods and limited choice of fruit and vegetables in heavily discounted stores have also been reported among disadvantaged women in the UK.^{32, 33} Women with lower educational attainment have reported poorer knowledge of diet-disease relationships, less control over family food choices and lower social support for healthy eating than highly educated women.^{32, 34} These findings suggest that women with low educational attainment have fewer economic and psychosocial resources to protect them against poorer environmental exposures, and may thus make their food choices heavily cued by environmental stimuli. Educational attainment is considered to underlie other socio-demographic markers such as employment status, job role and income level.³⁵ These factors are likely to directly affect health, but educational attainment may have an additional impact on health through increased critical thinking and sense of autonomy in determining employment, income, and health behaviours.³⁶

The unexpected inverse association between supermarket healthfulness and dietary quality among mothers with degrees may be explained by the increased use and growing market share of discount supermarkets, particularly Aldi and Lidl.³⁷ UK sales data shows that consumers are economising on grocery items and spending more at discount supermarkets to make their household budgets go further.^{38, 39} Mothers with degrees that shopped at discount supermarkets did not use the least healthful supermarkets; it was mothers with lower educational attainment who used these stores. It may be that mothers who are highly educated and highly health conscious choose to shop at more healthful discount chains for food budgeting reasons but employ shopping strategies such as a written shopping list which helps them maintain a purposeful course around the store and limits the influence of the less healthful supermarket environment.⁴⁰ Previous work which suggested that educational attainment confers a dietary advantage because of the increased sense of control over food

choices felt by more highly educated women supports this notion.⁴¹ In contrast, some mothers with few educational qualifications may have lower agency or reflective ability to monitor their shopping behaviour and rely more heavily on the supermarket environment and marketing cues to make food purchasing decisions thus making them more exposed to the lure of less healthy food.^{36, 40}

Strengths and limitations

This study used a measure of overall supermarket healthfulness which considered the combined effects of nine different variables that can influence consumer food choices, and rarely assessed factors including product placement and promotion. The standardisation enabled each of these factors to be represented equally in an overall score independent of whether they were categorical, dichotomous or continuous measures. The foods selected enabled assessment of the environmental exposures of foods included in the dietary assessment of participants.

This study has a number of limitations. The cross-sectional design of the study means that causal relationships between in-store exposures and dietary quality cannot be determined. There may also be problems generalizing the findings to populations outside Hampshire, UK and to different age groups. However, the FFQ used to determine mothers' dietary quality has discriminated between better and poorer dietary patterns among young children and older adults.^{24, 25} There is a risk of selection bias in this study, thus further research to confirm effect modification of educational attainment in larger samples and different areas is warranted.

Conclusions

Our findings suggest that the food choices of mothers with low educational attainment may be more heavily cued by environmental stimuli than those of mothers with higher educational attainment. Healthy eating interventions that address the environmental determinants of diet, particularly price strategies such as subsidies on fruit and vegetables in supermarkets, have been effective at improving dietary behaviours⁴²⁻⁴⁴ and are most likely to reduce dietary inequalities.⁴⁵ Policy initiatives that support cheaper pricing of healthy foods and greater varieties and promotion of healthy foods in less healthful discount supermarkets could help disadvantaged families to eat more healthy foods and address dietary inequalities.

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Contributions: CV and JB conceived of the study, designed the consumer nutrition environment tool, coordinated the data collection, healthfulness score development and wrote the first draft of the manuscript. GN and HMI created the dietary quality scores, contributed to the development of the supermarket healthfulness score and performed the statistical

323 analyses. CC, GM, SC and MEB participated in the design of the study and helped draft the
324 manuscript. All authors read and approved the manuscript.

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Titles of Figures

Figure 1. The relationship between thirds of supermarket healthfulness and dietary quality by level of educational attainment

Tables

Table 1. Characteristics of mothers presented by level of educational attainment

	Low education (≤16 years of age) n=304	Mid education n=293	High education (Degree) n=221	
	Mean (SD)			p-value
Dietary quality score	-0.46 (0.97)	-0.02 (0.90)	0.58 (0.88)	<0.001^a
Age at interview	31(6)	32 (6)	34 (5)	<0.001^a
Number of children	n (%)			
0	1 (0)	4 (1)	0 (0)	<0.001^b
1	109 (36)	114 (39)	108 (49)	
2	112 (37)	128 (44)	88 (40)	
3	54 (18)	37 (13)	19 (9)	
4+	28 (9)	10 (3)	5 (2)	
Neighbourhood deprivation				
Most deprived	90 (31)	63 (23)	13 (7)	<0.001^b
2	74 (25)	58 (21)	31 (16)	
3	73 (25)	81 (29)	70 (35)	
4	28 (10)	38 (14)	41 (20)	
Least deprived	25 (9)	36 (13)	45 (22)	
Paid employment				
No	205 (67)	167 (57)	125 (57)	0.01^a
Yes	99 (33)	126 (43)	96 (43)	
Type of main supermarket				
Premium supermarket	1 (0)	3 (1)	12 (5)	0.001^c
Large supermarket	280 (92)	274 (93)	196 (89)	
Discount supermarket	21 (7)	11 (4)	10 (5)	
Small supermarket	2 (1)	5 (2)	3 (1)	
Supermarket healthfulness score	Median (IQR)			
	1.73 (1.69, 1.94)	1.78 (1.73, 1.94)	1.78 (1.69, 1.86)	0.9 ^b

^a regression test for trend, ^b Spearman test for trend, ^c Fisher's exact test
Note: Boldface indicates statistical significance (p<0.05)

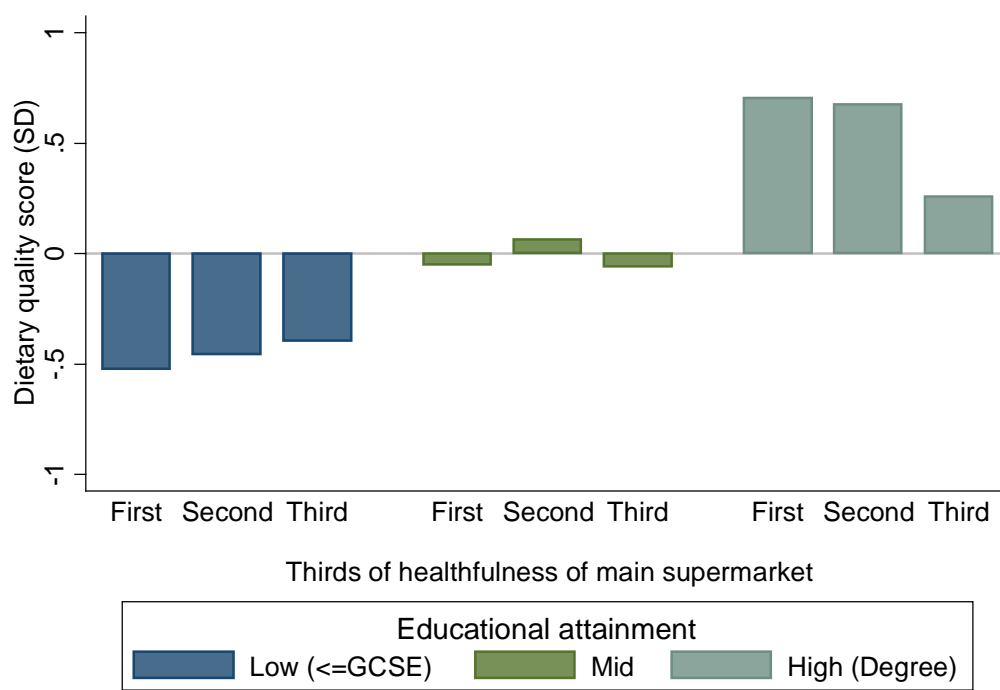
Table 2. Supermarket healthfulness scores according to the four types of supermarkets where mothers shopped

	Median healthfulness score SD (IQR)	Number of stores (%)	p-value
Type of supermarket			
Premium	1.80 (1.80, 1.80)	3 (6%)	
Large	1.78 (1.73, 1.94)	23 (47%)	
Discount	0.91 (0.16, 1.14)	16 (33%)	
Small	1.14 (0.95, 1.57)	7 (14%)	<0.001^a
^a Kruskal Wallis			
<i>Note:</i> Boldface indicates statistical significance (p<0.05)			

Table 3. Multi-level regression models for mothers' dietary quality and healthfulness of main supermarkets by educational attainment

	Dietary quality score SD β (95% CI)	
	<i>Unadjusted model</i>	<i>Adjusted model^a</i>
Low educational attainment (≤GCSE) Healthfulness score (SD)	0.36 (0.10, 0.61)	0.31 (0.07, 0.55)
Mid educational attainment Healthfulness score (SD)	-0.13 (-0.52, 0.27)	-0.13 (-0.56, 0.29)
High educational attainment (Degree) Healthfulness score (SD)	-0.54 (-1.08, -0.01)	-0.59 (-1.19, 0.00)
^a Confounding variables: age, number of children, neighbourhood deprivation, employment status; n=290 low educational attainment (≤GCSE), n=276 mid educational attainment, n=199 high educational attainment (degree)		

Figure 1. The relationship between thirds of supermarket healthfulness and dietary quality by level of educational attainment



Note: P-value for interaction = 0.006