

Education and the Relationship Between Supermarket Environment and Diet



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Introduction: Supermarkets are a major source of food for many families. Knowledge of how educational attainment affects the relationship between 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 to create a standardized “healthfulness” z-score for each supermarket where mothers shopped.

Results: Multilevel unadjusted linear regression analysis completed in 2014–2015 showed that shopping at more-healthy 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 educational attainment (interaction, $p=0.006$). Among mothers who left school at age 16 years, those who shopped at less healthy 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 healthy supermarkets had better dietary quality ($\beta=-0.59$ SD/SD, 95% CI=-1.19, 0.00).

Conclusions: Mothers with low educational attainment show greater susceptibility to less healthy 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.

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Introduction

Supermarkets are a major source of food for many families¹ and account for 87% of grocery sales in the United Kingdom (UK)² and \$630 billion of sales annually in the U.S.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 behaviors through initiatives at the environmental level by “nudging” people to make healthier choices.⁵ The premise of nudging is that much of human behavior is automatic, cued by environmental stimuli and largely unaccompanied by conscious reflection.⁶ It has been suggested that supermarkets offer a non-neutral environment that largely directs the food choices of an almost captive market in favor of energy-dense processed products with the greatest profit margin, which makes them an important site for intervention to improve dietary behaviors.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 behavior,^{10,11} affects this relationship.

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Systematic reviews^{9,12} examining the environmental determinants of diet reveal that research has focused on the effects of neighborhood access to food outlets, food price, and availability of healthy food. Although there is evidence from the U.S. that greater availability and cheaper pricing of healthy food is associated with healthier diets, evidence from other high-income countries is equivocal, and limitations in 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 optimize 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 (1) 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 (2) 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 while attending Sure Start Children's Centres.¹⁸ Mothers were asked questions about their age, number of children, highest attained educational qualification, employment status, and home postcode and indicated the supermarket where they did most of their food shopping (main supermarket). Home postcode was used to determine mothers' level of neighborhood 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.

Measures

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 non-communicable diseases.^{10,20} Mothers were asked to indicate how often in the previous month they consumed each of the 20 foods (6-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 standardized to have a mean of 0 and SD of 1. 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 characterized higher intakes of vegetables (e.g., peppers, tomatoes, lettuce) and wholemeal bread and lower intakes of processed meats (e.g., sausages), crisps, and sugar.

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 Owing 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 12 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 standardizing the result. The z-scores for the nine variables were then summed and divided by 9. This standardization and division ensured each in-store variable was equally weighted. Scores across the sample of 601 grocery stores and supermarkets were standardized to have a mean of 0 and SD of 1, and ranged from -1.86 to 2.15 . One-SD difference in healthfulness score is equivalent to a more healthful store having 11 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 are reported because after linking the supermarket data to mothers' individual data, the distribution of healthfulness scores became negatively skewed. These exposure measures were not normalized because they reflect the true variation in the environments mothers were exposed to.

Statistical Analysis

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 achieved at age 16 years; mid, Advanced Level/Higher National Diploma; high, tertiary degree) were assessed using a linear or logistic regression test for trend. Differences in number of children and neighborhood deprivation across the three education groups were assessed using Spearman test for trend, and differences in mothers' type of main supermarket were analyzed by Fisher's exact test.

In 2014–2015, multilevel 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 neighborhood 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

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. More than a third of mothers (37%) had no educational qualifications beyond age 16 years (low educational attainment). These mothers were younger, had more children, and lived in more deprived neighborhoods 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 age 16 years had a mean dietary quality score approximately 1 SD 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 1.78 SD (interquartile range, 1.69–1.94), 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, whereas large and premium supermarkets had the highest. There was almost 1 SD difference between these median scores.

Multilevel 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 (1) a strong positive relationship between dietary quality and store healthfulness among mothers with low educational attainment; (2) no significant association among mothers with mid educational attainment; and (3) 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 behaviors than previous work. Healthfulness of the main supermarket was positively

Table 1. Characteristics of Mothers Presented by Level of Educational Attainment

Characteristics	Low education (≤16 years of age) (n=304)	Mid education (n=293)	High education (degree) (n=221)	p-value
Dietary quality score, M (SD)	−0.46 (0.97)	−0.02 (0.90)	0.58 (0.88)	< 0.001 ^a
Age at interview, M (SD)	31 (6)	32 (6)	34 (5)	< 0.001 ^a
Number of children, n (%)				< 0.001 ^b
0	1 (0)	4 (1)	0 (0)	
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)	
Neighborhood deprivation, n (%)				< 0.001 ^b
Most deprived	90 (31)	63 (23)	13 (7)	
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, n (%)				0.01 ^a
No	205 (67)	167 (57)	125 (57)	
Yes	99 (33)	126 (43)	96 (43)	
Type of main supermarket, n (%)				0.001 ^c
Premium supermarket	1 (0)	3 (1)	12 (5)	
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

Note: Boldface indicates statistical significance ($p < 0.05$).

^aRegression test for trend.

^bSpearman test for trend.

^cFisher's exact test.

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, although it was mainly due to the effect of educational attainment.

There was strong evidence that educational attainment moderated the relationship between dietary quality and main supermarket healthfulness. Among mothers who had no qualifications beyond age 16 years, shopping at less healthful stores was associated with poorer dietary quality. By contrast, there was a 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, whereas those with higher educational attainment show greater resilience to the influence of poorer supermarket environments.

This 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

Table 2. Supermarket Healthfulness Scores According to the Four Types of Supermarkets Where Mothers Shopped

Type of supermarket	Median healthfulness score, SD (IQR)	Number of stores (%)	p-value
Premium	1.80 (1.80, 1.80)	3 (6%)	
Large	1.78 (1.73, 1.94)	23 (47%)	< 0.001^a
Discount	0.91 (0.16, 1.14)	16 (33%)	
Small	1.14 (0.95, 1.57)	7 (14%)	

Note: Boldface indicates statistical significance ($p < 0.05$).

^aKruskal–Wallis.

IQR, interquartile range.

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 5,000 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 U.S. study²⁸ 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. Another U.S. study²⁹ 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. The lack of consistency in findings between these

Table 3. Multilevel Regression Models for Mothers' Dietary Quality and Healthfulness of Main Supermarkets by Educational Attainment

	Dietary quality score SD β (95% CI)	
	Unadjusted model	Adjusted model ^a
Low educational attainment (\leq 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)

^aConfounding variables: age, number of children, neighborhood deprivation, employment status; $n=290$ low educational attainment (\leq GCSE), $n=276$ mid educational attainment, $n=199$ high educational attainment (degree).

GCSE, General Certificate of Secondary Education.

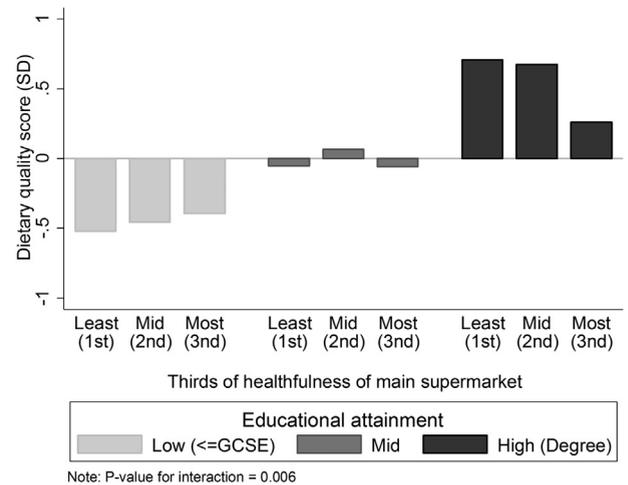


Figure 1. The relationship between thirds of supermarket healthfulness and dietary quality by level of educational attainment.

GCSE, General Certificate of Secondary Education.

studies and the current study may be explained by methodological differences. The U.S. studies focused on the availability of healthy products, whereas 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 U.S. identified two competing levels of influence on food shopping behavior.^{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 sociodemographic 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 behaviors.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 economizing 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 that 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 By contrast, some mothers with few educational qualifications may have lower agency or reflective ability to monitor their shopping behavior 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 foods.^{36,40}

Limitations

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

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 behaviors^{42–44} 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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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 analyses. CC, GM, SC, and MEB participated in the design of the study and

helped draft the manuscript. All authors read and approved the manuscript.

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