ORIGINAL ARTICLE

Association between home and school food environments and dietary patterns among 9–11-year-old children in 12 countries

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OBJECTIVES: We investigated the roles of home and school environments on dietary patterns among children from 12 countries differing widely in geographic region and levels of human and economic development.

METHODS: The sample included a total of 6685 (54% girls) 9–11-year-old children. Parents/guardians reported the availability of certain foods in the home, and trained researchers performed school audits recording the availability of foods for sale at schools. Foods were then divided into wholesome (nutrient-dense) and empty-calorie (nutrient-poor) foods and scored according to their availability. Children reported if their school provided school lunch and how many times during the last week they had eaten meals prepared away from home and school. Via principal components analysis, data-driven dietary pattern scores were calculated from food frequency questionnaires. Multilevel models were used to study the associations between home and school food environments (wholesome and empty-calorie foods) and dietary patterns (healthy and unhealthy diet pattern scores).

RESULTS: For low unhealthy diet pattern scores, low availability of empty-calorie foods at home was found to be more important than high availability of wholesome foods. More meals eaten outside home and school were associated with the higher unhealthy diet pattern scores. The availability of wholesome foods at home was positively associated with the healthy diet pattern scores. Food availability at school was not associated with the dietary patterns.

CONCLUSIONS: In this sample, the home food environment was more significant than the school food environment in predicting the dietary patterns. The availability of empty-calorie foods was associated with the unhealthy dietary pattern even when the availability of wholesome foods at home was high. Meals prepared away from home contributed to the unhealthy dietary pattern. Therefore, parents should be encouraged to limit the availability of empty-calorie foods and eating outside the home.

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INTRODUCTION

In the late twentieth century, the prevalence of non-communicable diseases has declined remarkably in high-income countries, but in low- and middle-income countries, the opposite has been observed.¹ In addition, the prevalence of childhood obesity is also increasing in several low- and middle-income countries.² Individual factors such as genes, gender and age have an effect on weight, obesity and health behaviors in general.^{3,4} However, the ecological framework of health promotion states that social and physical environmental factors also influence health behaviors.⁵ Part of the physical environment influencing health behaviors, such as food choices, is the food environment, which has been conceptualized to include any opportunity to obtain food.⁶

Natural food environments in the life of a 9–11-year-old child revolve around home and school. Parents have a fundamental role in providing food availability at home, and consequently home settings are the least accessible for health promotion interventions.⁷ Schools, however, have been used widely as a setting for these interventions, as they can reach a large

population from different ethnic, socioeconomic and cultural backgrounds. It has been advanced that the prevalence of obesity among children, for example, can probably be decreased using multisetting approaches engaging both schools and the children's families and thus the home environment too.⁸ To this end, further information about environmental factors associated with food behaviors at home and school is required to build more effective interventions.

Recent reviews have suggested that food environments at home, in the neighborhood, and at school may be associated with children's diet or obesity-related outcomes.^{9–11} At home, the availability of nutrient-poor ('empty-calorie') foods have been shown to be associated with unhealthy food intake.^{12,13} Conversely, limited access to unhealthy foods may be associated with healthy food intake.¹⁴ Food environments at school have received less research attention. Indeed, to our knowledge, no studies comparing the impact of food environments at home and school on dietary behavior in children exist.

To date, studies focusing on food environment have mainly been conducted in single, western countries (for example, the

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United States and the United Kingdom). As it has been suggested that dietary patterns among 10-year-old children are quite similar across the globe,¹⁵ we wanted to examine whether food environments are similarly associated with dietary patterns in different cultural settings. Accordingly, in the present paper, we investigated the associations between food environments and dietary patterns among 9–11-year-old children in 12 culturally different sites around the globe. There were two specific objectives: (1) to study the associations between the availability of wholesome and empty-calorie foods at home and at school on dietary patterns among schoolchildren; and (2) to investigate and compare the roles of home and school food environments as correlates of these dietary patterns.

MATERIALS AND METHODS

Setting and participants

The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) was designed to investigate the relationships between lifestyle behaviors and obesity in children.¹⁶ The participants were 9–11-year-old children from study sites in semi-urban and urban areas of Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom and the United States. The recruitment and data collection protocols are described in detail elsewhere.¹⁶ The Institutional Review Board at the Pennington Biomedical Research Center (coordinating center) approved the study protocol, and the Institutional/Ethical Review Boards at each participating institution also approved the local protocol. Children provided their assent to participate in the study, and parents or legal guardians provided informed consent.

In total, 7806 children assented and received parental legal guardian consent to participate in the study. The overall study sample consisted of 7372 (94%) children,¹⁷ of which 6685 participants (91% of the overall study sample, 54% girls) were included in the present analyses. A total of 687 (9%) children with missing information regarding home environmental factors or dietary behavior were excluded from the analyses. The excluded children did not differ significantly from those included in the analysis with respect to gender or body mass index, but there were notable differences between sites. The inclusion rates were above 90% in Colombia, China, Canada, India, Australia, Kenya and Finland, but lower in the United Kingdom and the United States (87% in both), Brazil (86%), Portugal (83%) and South Africa (65%). There were no significant differences in dietary pattern scores (see methods below) between those with and without information on home food availability.

Definitions

In the present analyses, we use concepts defined as follows. Food environment refers to the availability of certain foods in the home or at school. We use the word 'empty-calorie' to describe foods that are energy-dense and nutrient-poor, whereas 'wholesome' is used to mean foods that are nutrient-dense or can act as healthier alternatives to nutrient-poor foods. Dietary patterns are defined as combinations of foods and drinks and the frequency of consumption within the study population. Earlier, we identified two dietary patterns and named them 'unhealthy diet pattern' and 'healthy diet pattern'.¹⁵ In the statistical models, we use the availability of empty-calorie and wholesome foods in the home and at school as exposures. Conversely, principal component scores for the two dietary patterns (unhealthy and healthy diet pattern scores) are used as dependent variables.

Home and school food environments

The parents/legal guardians of the participating children reported how often specified foods were available in the home using a structured questionnaire. Food items included in the questionnaire were chocolate candy; other candy; raw fruit; cakes, brownies, muffins or cookies; regular chips or crackers; baked chips, low-fat crackers, pretzels; raw vegetables; 100% fruit juice; juice drinks; regular sodas with sugar; diet or sugar-free sodas; sports drinks; fruit roll-ups or other dried fruit; regular or 2% milk; 1% or fat-free milk; sweetened breakfast cereal and unsweetened breakfast cereal. On the basis of many current dietary guidelines¹⁸ and a presumption that some of the foods may act as healthier alternatives to more unhealthy choices, we considered raw fruit, raw vegetables, 100%

fruit juice, 1% or fat-free milk and unsweetened breakfast cereal as wholesome foods. Their availability at home was scored according to the response categories from 1 (never) to 5 points (always) leading to a summary score ranging from 5 to 25. Conversely, we considered chocolate candy; other candy; cakes, brownies, muffins or cookies; regular chips or crackers; juice drinks; regular sodas with sugar; sports drinks and sweetened breakfast cereal as empty-calorie foods, and their availability at home was scored similarly leading to a summary score from 8 to 40.

We measured food environment at school using environmental audits performed by specially trained ISCOLE study staff in each participating school.¹⁶ The auditors reported the sale of several foods in school cafeterias and/or vending machines. On the basis of these auditors' reports, the sale of 100% fruit or 100% vegetable juice; low-fat or skim milk (flavored or regular); water; fruit (fresh, frozen, canned or dried); breadsticks, rolls, bagels, pita bread or other bread products; low-fat or non-fat yogurt; lettuce, vegetable or bean salads; other vegetables; nuts; and trail mix were scored with one point for each selling point (cafeteria and/or vending machine) leading to a wholesome food score ranging from 0 to 13. Similarly, the availability of sugar-sweetened beverages (soft drinks, sports drinks or fruit drinks that are not 100% juice); cookies, crackers, cakes, pastries or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat; pizza, hamburgers, sandwiches, meat pies and other baked savory pastries; French fried potatoes; chocolate candy; other candy and salty snacks that are not low in fat, such as regular potato chips or cheese puffs at each selling point (cafeteria and/or vending machine) was computed to create an empty-calorie food score ranging from 0 to 11.

In addition, the children reported how many meals (breakfast, lunch or dinner) prepared away from home in places such as restaurants, fast-food places, food stands, grocery stores or vending machines they consumed during the past week. The children also reported if their school served school lunch (yes or no).

Dietary patterns

Children reported their usual consumption frequency of 23 different food groups using a validated food frequency questionnaire (FFQ).¹⁹ Items in the FFQ used were not identical with the food availability questionnaire used to assess home food environment. To identify existing dietary patterns, we carried out principal components analysis using the FFQ food groups as input variables. The analyses were performed for each site separately. Detailed information on the dietary assessment methods and the identification of dietary patterns can be found elsewhere.^{15,19} In brief, for each site we chose two components, which were rotated with an orthogonal varimax transformation to enhance the interpretation, and based on food group loadings labeled them as 'unhealthy diet pattern' (characterized by high intakes of, for example, fast foods, ice cream, fried food, French fries and potato chips) and 'healthy diet pattern' (including, for example, dark-green vegetables, orange vegetables, vegetables in general and fruits and berries). In the present paper, we use standardized principal component scores for these two patterns as the dependent variables (unhealthy and healthy diet pattern scores).

Statistical analyses

The associations between the food environment scores and the diet pattern scores were assessed using multilevel linear mixed models (PROC MIXED of SAS statistical package version 9.3; SAS Institute Inc., Cary, NC, USA). Study sites were considered to have fixed effects, and schools nested within study sites were viewed as having random effects. The denominator degrees of freedom for statistical tests pertaining to fixed effects were calculated using the Kenward and Roger approximation.²⁰ Home food environment scores within the whole study sample were categorized into quarters based on their distribution and those with the lowest scores were set as the reference group. Schools selling no foods at all were set as the reference group, and the remaining schools were divided into thirds according to the wholesome or empty-calorie school food environment score. The number of meals outside home and school was included in the models as a continuous variable and the availability of school lunch as a dichotomous variable (yes/no) with 'no' as the reference group. We investigated the crude associations with multilevel univariate models (adjusted only for gender) and used multivariable models to identify the possible independent roles of the food environments in the home and at school. We also calculated the gender-adjusted least square means of the diet pattern scores in different combinations of home and school food

environment categories to illustrate the differences between groups. Initial analyses were carried out for both genders separately, but due to similar results, girls and boys were combined in the final analyses and gender was included as a covariate in all models.

RESULTS

Home and school food environments

The sample consisted of 6685 children (54% girls) with mean age of 10.4 (s.d. 0.6) years from 12 study sites. On average, the children scored 18.0 points on the wholesome food score at home (Table 1). Children in the United Kingdom, Australia and Canada scored highest, whereas the children in Brazil, China and Kenya had the lowest scores. Regarding the empty-calorie food score at home, the highest scores and hence apparently the most unhealthy home food environments were found in the United States, South Africa and the United Kingdom. Lowest availabilities of empty-calorie foods were found in Finland, Kenya and China. The number of meals eaten outside home and school was on average 2.0 during the past week. On average, the US and South-African children had more than three meals prepared away from home during the week, whereas the respective number among Portuguese children was less than one. In some sites, most children reported that their school served school lunch (> 90% in Finland, China, Portugal, the United Kingdom, the United States and Kenya), whereas the lowest proportion was reported in India (18%).

The participants were from 256 schools, of which 50% sold food in the canteen, cafeteria or in the vending machines (Table 2). No foods were on sale in the Canadian or Chinese schools. The percentages of schools selling foods were highest in Portugal, South Africa and Colombia. In total, the number of empty-calorie foods was higher than the number of wholesome foods on sale at schools. Schools in Australia, Finland, Portugal and the United Kingdom had numerically more wholesome than empty-calorie foods available. The correlation coefficients between home and school food environment scores and meals eaten outside home and school were mostly weak (Pearson correlation coefficients ranged from -0.14 to 0.19, data not shown). The availability of wholesome foods at school correlated weakly with the availability of empty-calorie foods at school (Pearson correlation coefficient 0.28, $P = 0.0016$; schools not selling any foods excluded).

Food environment and unhealthy diet pattern scores

The first column in Table 3 shows results from five univariate multilevel models testing the gender-adjusted associations between home and school food environments and unhealthy diet pattern scores. The availability of empty-calorie foods at home was positively and that of wholesome foods inversely associated with unhealthy diet pattern scores. School food environment was not associated with unhealthy diet pattern scores, but the number of meals eaten outside home and school was positively associated with unhealthy diet pattern scores.

The second column in Table 3 describes results from a multivariable multilevel model consisting of empty-calorie food availabilities at home and school and meals eaten outside home and school. In this model, the number of empty-calorie foods available at home and meals eaten out were independently associated with unhealthy diet pattern scores, whereas the school food environment had no significant associations. The third column shows another multilevel model with home food environment and meals eaten outside home and school. When entered in the model simultaneously, empty-calorie foods available at home were positively and wholesome foods inversely associated with unhealthy diet pattern scores suggesting an independent role of them both. Furthermore, we detected an interaction effect between the availability of empty-calorie and

Table 1. Children's home food environment scores, the number of meals eaten outside home and school lunch availability

Site	Number of participants (% girls)	Wholesome food ^a score ^b (mean, (s.d.))	Empty-calorie food ^c score ^d (mean, (s.d.))	Number of meals eaten outside home and school (mean, (s.d.)) ^e during 1 week	Participant's school serves school lunches (%)
Australia (Adelaide)	498 (54)	21.6 (2.7)	23.3 (4.6)	1.7 (2.5)	77
Brazil (São Paulo)	502 (51)	15.1 (3.6)	22.8 (4.1)	1.9 (2.5)	89
Canada (Ottawa)	556 (58)	21.2 (3.0)	22.3 (4.7)	1.4 (2.0)	53
China (Tianjin)	549 (47)	16.1 (2.9)	20.8 (4.5)	2.3 (3.0)	98
Colombia (Bogotá)	918 (51)	16.4 (3.5)	21.9 (5.2)	1.2 (1.7)	46
Finland (Helsinki, Espoo and Vantaa)	491 (53)	19.9 (2.8)	20.6 (3.7)	1.7 (2.6)	100
India (Bangalore)	599 (53)	16.8 (3.5)	21.2 (5.1)	2.2 (2.7)	18
Kenya (Nairobi)	537 (54)	16.2 (3.6)	20.7 (5.2)	2.4 (2.8)	95
Portugal (Porto)	637 (56)	16.9 (3.3)	21.0 (4.2)	0.9 (1.3)	98
South Africa (Cape Town)	364 (60)	16.7 (4.2)	25.0 (5.9)	3.1 (3.2)	82
United Kingdom (Bath and Somerset)	454 (55)	22.4 (2.5)	23.6 (4.8)	1.4 (2.1)	98
United States of America (Baton Rouge)	598 (57)	18.0 (3.4)	26.6 (5.5)	3.9 (3.5)	97
All	6685 (54)	18.0 (4.0)	22.4 (5.1)	2.0 (2.6)	77

^aRaw fruit; raw vegetables; 100% fruit juice; 1% or fat-free milk; unsweetened breakfast cereal. ^bAvailability of wholesome foods at home scored according to the response categories from 1 (never) to 5 (always) leading to a sum score ranging from 5 to 25. ^cChocolate candy; other candy; cakes, brownies, muffins or cookies; regular chips or crackers; juice drinks; regular sodas with sugar; sports drinks; sweetened breakfast cereal. ^dAvailability of empty-calorie foods at home scored according to the response categories from 1 (never) to 5 (always) leading to a sum score ranging from 8 to 40. ^eValues 11 and greater coded as 11.

Table 2. Number of wholesome and empty-calorie foods available at schools and number of schools not selling foods

Site	Number of schools	Number of wholesome foods ^a available at school (mean, (s.d.)) ^b	Number of empty-calorie foods ^c available at school (mean, (s.d.)) ^b	Number of schools not selling foods (% of all schools)
Australia (Adelaide)	26	5.5 (2.0)	4.1 (1.5)	6 (23)
Brazil (São Paulo)	24	2.9 (2.5)	4.7 (2.7)	12 (50)
Canada (Ottawa)	26	0 (0)	0 (0)	26 (100)
China (Tianjin)	6	0 (0)	0 (0)	6 (100)
Colombia (Bogotá)	20	3.5 (2.2)	7.5 (1.0)	1 (17)
Finland (Helsinki, Espoo and Vantaa)	25	4.9 (1.5)	3.0 (0.6)	18 (72)
India (Bangalore)	10	2.5 (1.1)	6.1 (1.8)	2 (20)
Kenya (Nairobi)	29	1.4 (1.1)	3.4 (2.3)	19 (66)
Portugal (Porto)	23	5.5 (1.7)	4.7 (1.5)	0 (0)
South Africa (Cape Town)	20	0.8 (1.2)	4.4 (1.5)	2 (10)
United Kingdom (Bath and Somerset)	26	2.5 (1.4)	0.9 (1.1)	18 (69)
United States of America (Baton Rouge)	21	0 (0)	3.5 (0.7)	19 (90)
All	256	3.5 (2.5)	4.6 (2.2)	129 (50)

^a100% fruit or 100% vegetable juice; low-fat or skim milk (flavored or regular); water; fruit (fresh, frozen, canned or dried); breadsticks, rolls, bagels, pita bread or other bread products; low-fat or non-fat yogurt; lettuce, vegetable or bean salads; other vegetables; nuts; trail mix. ^bCalculated as means and s.d.'s from the schools selling foods. ^cSugar-sweetened beverages (soft drinks, sports drinks or fruit drinks that are not 100% juice); cookies, crackers, cakes, pastries or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat; pizza, hamburgers, sandwiches, meat pies and other baked savory pastries; French fried potatoes; chocolate candy; other candy; salty snacks that are not low in fat, such as regular chips or cheese puffs.

wholesome foods at home ($P < 0.0001$). In the home environment, abundance of empty-calorie foods seemed to partly overrule the inverse relation of wholesome food availability and unhealthy diet pattern score (Figure 1). Number of meals eaten outside home and school was positively and independently associated with unhealthy diet pattern score, whereas school lunch availability had no associations (Table 3). Site interactions and saturated models with all the exposure variables were also tested, but the results did not change (data not shown).

Food environment and healthy diet pattern scores

The first column in Table 4 shows results from five different univariate models testing the associations between home and school food environments and healthy dietary pattern. The number of wholesome foods available at home was positively and that of empty-calorie foods inversely associated with healthy diet pattern scores. School food environment and meals eaten outside home and school were not associated with healthy diet pattern scores.

The second column in Table 4 shows results from a multivariable model consisting of wholesome food environments at home and school as well as meals eaten outside home and school. The number of wholesome foods available at home was associated with healthy diet pattern score. In the second multivariable model (the third column in Table 4), again, the number of wholesome foods available at home was positively, and the number of empty-calorie foods inversely associated with healthy diet pattern score. Figure 2 illustrates healthy diet pattern scores in thirds and quarters of wholesome food availability at school and in the home, respectively. The saturated model with all the exposure variables was also tested, but the results did not change (data not shown).

DISCUSSION

In the present study, the home food environment was associated with both unhealthy and healthy dietary patterns, whereas the school food environment in general was not. However, children with high availability of wholesome foods in the home seemed to be able to choose healthier foods also at school. Meals eaten outside of the home and school were significantly associated with the unhealthy, but not with the healthy dietary pattern.

Children whose parents/guardians reported greater amounts of wholesome foods available at home scored lower on the unhealthy diet pattern score and higher in the healthy diet pattern score. However, children with high availability of both wholesome and empty-calorie foods at home scored higher in the unhealthy diet pattern score. Thus, the availability of wholesome foods at home did not protect the children from choosing readily available empty-calorie foods. We are not aware of similar previous findings. With an adult sample, Gustafson *et al.*²¹ reported that people shopping in supermarkets with high availability of healthy foods were less likely to consume sugar-sweetened beverages compared with those shopping in supermarkets with low availability of healthy foods. However, due to the design of the above study, it is not possible to prove a causality between different food environments and consumption. It is possible that compared with adults, children are less able to resist such temptations when being surrounded by empty-calorie foods. In fact, it has been shown that although both children and adults are attracted to unhealthy food, adults—unlike children—are able to shift their attention away from unhealthy food.²² In addition, knowledge about healthy foods may guide the food choices of adults more than those of children. In any case, parents are responsible for the foods available at home, and empty-calorie foods at home may also describe parents' own preferences rather than those of their children. In the present study, we did not measure the diet of the parents. Thus, it is unknown if the children consumed empty-calorie foods on their own or as part of the meals prepared and/or served by their parents.

To our knowledge, no studies investigating the associations between home food environment and diet quality in children have been conducted using such a geographically and socioeconomically diverse sample as ISCOLE. In related work with 187 US Hispanic children, Santiago-Torres *et al.*²³ found that the availability of sugar-sweetened beverages was associated with lower Healthy Eating Index score. Similarly, Couch *et al.*¹³ reported a positive association between the availability of low-calorie foods and Dietary Approaches to Stop Hypertension score, whereas the availability of high-calorie foods was inversely associated with Dietary Approaches to Stop Hypertension score among children. In a cross-sectional study, participants who did not have fruit and vegetables always available at home were more likely to eat fruit and vegetables less than recommended compared with participants who always had fruit and vegetables available at home.²⁴ However, in a study conducted in

Table 3. Correlates of unhealthy dietary pattern: univariate (first column) and multivariable models (second and third columns) describing the associations between home and school food environments and unhealthy diet pattern scores

	Univariate models			Multivariable model 1: empty-calorie foods at home and school, meals outside home and school			Multivariable model 2: empty-calorie and wholesome foods at home, meals outside home and school		
	β	s.e.	P-value	β	s.e.	P-value	β	s.e.	P-value
Home									
Availability of empty-calorie foods ^a									
1 ^b	ref			ref			ref		
2	0.11	0.03	0.002	0.11	0.03	0.002	0.12	0.03	0.0006
3	0.26	0.04	< 0.001	0.26	0.04	< 0.0001	0.26	0.03	< 0.0001
4	0.40	0.03	< 0.0001	0.39	0.03	< 0.0001	0.41	0.03	< 0.0001
Availability of wholesome foods ^c									
1 ^d	ref						ref		
2	-0.08	0.04	0.03				-0.11	0.03	0.001
3	-0.07	0.04	0.04				-0.13	0.04	0.0007
4	-0.19	0.03	< 0.0001				-0.25	0.04	< 0.0001
School									
Availability of empty-calorie foods ^e									
No shops ^f	ref			ref					
1	-0.09	0.07	0.22	-0.05	0.07	0.54			
2	-0.02	0.06	0.79	-0.01	0.07	0.86			
3	-0.03	0.07	0.71	0.07	0.08	0.80			
Availability of wholesome foods ^g									
No shops ^h	ref								
1	0.06	0.08	0.48						
2	-0.09	0.06	0.17						
3	0.00	0.06	0.96						
Other									
Meals outside home and school ⁱ	0.08	0.005	< 0.0001	0.08	0.005	< 0.0001	0.08	0.005	< 0.0001
School lunches									
No	ref								
Yes	0.05	0.04	0.10						

^aChocolate candy; other candy; cakes, brownies, muffins or cookies; regular chips or crackers; juice drinks; regular sodas with sugar; sports drinks; sweetened breakfast cereal. ^bQuarters of empty-calorie food score (ranges 8–18; 19–21; 22–24; 25–40). ^cRaw fruit; raw vegetables; 100% fruit juice; 1% or fat-free milk; unsweetened breakfast cereal. ^dQuarters of wholesome food score (ranges 5–14; 15–17; 18–20; 21–25). ^eSugar-sweetened beverages (soft drinks, sports drinks or fruit drinks that are not 100% juice); cookies, crackers, cakes, pastries or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat; pizza, hamburgers, sandwiches, meat pies and other baked savory pastries; French fried potatoes; chocolate candy; other candy; salty snacks that are not low in fat, such as regular chips or cheese puffs. ^fSchools selling no food at all used as reference group, the rest of the schools divided into thirds based on the empty-calorie food score (ranges 1–3; 4–6; 7–10). ^g100% fruit or 100% vegetable juice; low-fat or skim milk (flavored or regular); water; fruit (fresh, frozen, canned or dried); breadsticks, rolls, bagels, pita bread or other bread products; low-fat or non-fat yogurt; lettuce, vegetable or bean salads; other vegetables; nuts; trail mix. ^hSchools selling no food at all used as reference group, the rest of the schools divided into thirds based on the wholesome food score (ranges 1–2; 3–5; 6–8). ⁱContinuous variable. All models adjusted by gender.

Figure 1. Unhealthy diet pattern scores in quarters of wholesome (horizontal axis) and empty-calorie foods (vertical axis) available at home.

Puerto Rico, the number of unhealthy or healthy foods at home was not associated with diet quality measured by Healthy Eating Index.²⁵ Thus, our results are in line with previous studies emphasizing the importance of home food environment, especially regarding foods considered unhealthy.

In our data, no significant associations between the school food environment and dietary patterns existed. There are several reasons that may explain this finding. First, most children usually eat only once or twice a day (typically lunch and possibly a snack) at school, whereas the major part of the daily foods are consumed at home or at least outside of school. Moreover, and as in some countries children brought the food they consume at school from home (packed lunch), the impact of their home food environment extends from home to school. Second, in our study, only 50% of the participating schools sold any foods at all making it more difficult to detect the possible differences. In addition, schools may restrict the selling of unhealthy foods based on health policies. They may also have rules on the nutritional quality of foods brought from home. On the other hand, 10-year-old children may have some money of their own, and in some countries they may be able to leave the school premises and buy

Table 4. Correlates of healthy dietary pattern: univariate (first column) and multivariable models (second and third columns) describing the associations between home and school food environments and healthy diet pattern scores

	Univariate models			Model 1: wholesome foods at home and school, meals outside home and school			Model 2: wholesome and empty-calorie foods at home, meals outside home and school		
	β	s.e.	P-value	β	s.e.	P-value	β	s.e.	P-value
Home									
Availability of wholesome foods ^a									
1 ^b	ref			ref			ref		
2	0.20	0.04	< 0.0001	0.19	0.04	< 0.0001	0.23	0.04	< 0.0001
3	0.20	0.04	< 0.0001	0.20	0.04	< 0.0001	0.24	0.04	< 0.0001
4	0.33	0.04	< 0.0001	0.33	0.04	< 0.0001	0.38	0.04	< 0.0001
Availability of empty-calorie foods ^c									
1 ^d	ref						ref		
2	-0.05	0.04	0.13				-0.08	0.04	0.04
3	-0.11	0.04	0.003				-0.14	0.04	0.0001
4	-0.15	0.03	< 0.0001				-0.20	0.04	< 0.0001
School									
Availability of wholesome foods ^e									
No shops ^f	ref			ref					
1	-0.03	0.07	0.69	0.01	0.07	0.87			
2	0.01	0.05	0.85	0.02	0.06	0.78			
3	-0.03	0.05	0.48	-0.04	0.06	0.53			
Availability of empty-calorie foods ^g									
No shops ^h	ref								
1	-0.03	0.06	0.58						
2	-0.06	0.05	0.24						
3	0.01	0.05	0.80						
Other									
Meals outside home and school ⁱ	0.01	0.005	0.25	0.005	0.005	0.31	0.009	0.005	0.07
School lunches									
No	ref								
Yes	-0.05	0.04	0.23						

^aRaw fruit; raw vegetables; 100% fruit juice; 1% or fat-free milk; unsweetened breakfast cereal. ^bQuarters of wholesome food score (ranges 5–14; 15–17; 18–20; 21–25). ^cChocolate candy; other candy; cakes, brownies, muffins or cookies; regular chips or crackers; juice drinks; regular sodas with sugar; sports drinks; sweetened breakfast cereal. ^dQuarters of empty-calorie food score (ranges 8–18; 19–21; 22–24; 25–40). ^e100% fruit or 100% vegetable juice; low-fat or skim milk (flavored or regular); water; fruit (fresh, frozen, canned or dried); breadsticks, rolls, bagels, pita bread or other bread products; low-fat or non-fat yogurt; lettuce, vegetable or bean salads; other vegetables; nuts; trail mix. ^fSchools selling no food at all used as reference group, the rest of the schools divided into thirds based on the wholesome food score (ranges 1–2; 3–5; 6–8). ^gSugar-sweetened beverages (soft drinks, sports drinks or fruit drinks that are not 100% juice); cookies, crackers, cakes, pastries or other baked goods that are not low in fat; ice cream or frozen yogurt that is not low in fat; pizza, hamburgers, sandwiches, meat pies and other baked savory pastries; French fried potatoes; chocolate candy; other candy; salty snacks that are not low in fat, such as regular chips or cheese puffs. ^hSchools selling no food at all used as reference group, the rest of the schools divided into thirds based on the empty-calorie food score (ranges 1–3; 4–6; 7–10). ⁱContinuous variable. All models adjusted by gender.

Figure 2. Healthy diet pattern scores in thirds and quarters of wholesome foods available at school (horizontal axis) and in the home (vertical axis).

food items outside school. In addition, the school setting varied widely across the sampled schools (for example, grade levels and size). Hence, it is possible that we were not able to measure the availability of all foods during a school day accurately. School neighborhood, which was not included in the present analyses, has been linked to diet quality among children in Canada and New Zealand.^{26,27}

We found an association between eating out and the unhealthy dietary pattern. Previously, it has been advanced that eating out contributes significantly to daily energy intake and is associated with lower dietary quality.²⁸ These findings are not surprising, as foods marketed to children at restaurants are often high in energy density and low in micronutrient density.²⁹ It would be important to develop healthier eating-out alternatives for children and adolescents, but to combine health and attractiveness is obviously a great challenge. We did not find any associations between school lunch availability and dietary patterns. There are great differences between how school lunch is provided in different countries. In some countries, such as Finland, the lunch is free for everyone and there is only one option daily available. In many other countries, school lunch is subject to a charge but free for

children from low-income families, which might lead to socio-economic differences between those who have school lunch and those who bring lunch from home. The role of school lunch availability in children's food consumption should thus be studied further.

In this work, parents reported the availability of foods at home, whereas children reported on their food behavior. We believe that the use of separate informants decreased the chance of contamination in the two questionnaires used. In addition, the food items listed in the two questionnaires were not identical. However, in the validation study of the ISCOLE FFQ,¹⁹ some misreporting of food intake based on social desirability was observed; the consumption frequency of three food groups representing recommended, healthy foods was slightly overestimated, whereas the food group 'cakes and so on' was underestimated. We used previously identified dietary patterns and scores representing the overall quality of diet as the outcome variables.¹⁵ The data-driven, whole-diet approach has several advantages over hypothesis-driven methods or analysis focusing on individual foods or nutrients, but is dependent on many subjective decisions, and may thus fail to capture all aspects of dietary behavior and its determinants. It is possible that, for example, school food environment has an effect on particular food choices other than those illustrated by the dietary patterns. Furthermore, due to the multilevel approach of the analyses in which school was treated as one level, the statistical power is substantially smaller at the school level than at the individual level. However, the effect sizes for diet pattern scores in thirds of school food environment showed no trend. Thus, it is presumable, that the substantially smaller statistical power at school level did not affect our results considerably.

We used indices of home and school food environment as the determinants of the dietary pattern scores. As for any index, their construction was dependent on our own subjective decisions on classifying the foods into wholesome and empty-calorie categories. We based our classification mainly on the known or anticipated nutritional values of the food items; a presumption of the food being a healthier/unhealthier alternative to another corresponding product was also considered (for example, water as an alternative to sugar-sweetened beverages). In the assessment of the school food environment score, we included only foods that could be chosen by the children themselves. School lunch availability was investigated separately, but the content of the foods offered was not known.

In conclusion, the food environment at home was more significant than the school food environment as a correlate of dietary patterns in 9–11-year-old children from a geographically and culturally diverse sample representing urban and semi-urban regions. The availability of empty-calorie foods at home was associated with an unhealthy dietary pattern and inversely associated with a healthy dietary pattern. These results suggest that limiting the availability of empty-calorie foods at home should have a role in designing interventions and campaigns for promoting healthy eating in children. The international design of ISCOLE extends these conclusions to countries of very different developmental level, culture and geographical location.

CONFLICT OF INTEREST

MF has received a research grant from Fazer Finland and has received an honorarium for speaking for Merck. AK has been a member of the Advisory Boards of Dupont and McCain Foods. RK has received a research grant from Abbott Nutrition Research and Development. VMA is a member of the Scientific Advisory Board of Actigraph and has received an honorarium for speaking for The Coca-Cola Company. TO has received an honorarium for speaking for The Coca-Cola Company. The remaining authors declare no conflict of interest.

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