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Local food environments are associated with girls' energy, sugar-sweetened beverage and snack-food intakes

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Abstract

Objective: To describe availability and frequency of use of local snack-food outlets and determine whether reported use of these outlets was associated with dietary intakes.

Design: Data were cross-sectional. Availability and frequency of use of three types of local snack-food outlets were reported. Daily dietary intakes were based on the average of up to four 24 h dietary recalls. Multivariable linear regression models estimated average daily intakes of energy, sugar-sweetened beverages (SSB) and snack foods/sweets associated with use of outlets.

Setting: Multi-site, observational cohort study in the USA, 2004–2006.

Subjects: Girls aged 6–8 years (*n* 1010).

Results: Weekly frequency of use of local snack-food outlets increased with number of available types of outlets. Girls with access to only one type of outlet reported consuming food/beverage items less frequently than girls with access to two or three types of outlets ($P < 0{\cdot}001$). Girls' daily energy, SSB and snack foods/sweets intakes increased with greater use of outlets. Girls who reported using outlets > 1 to 3 times/week consumed 0·27 (95 % CI 0·13, 0·40) servings of SSB more daily than girls who reported no use. Girls who reported using outlets > 3 times/week consumed 449·61 (95 % CI 134·93, 764·29) kJ, 0·43 (95 % CI 0·29, 0·58) servings of SSB and 0·38 (95 % CI 0·12, 0·65) servings of snack foods/sweets more daily than those who reported no use.

Conclusions: Girls' frequency of use of local snack-food outlets increases with the number of available types of outlets and is associated with greater daily intakes of energy and servings of SSB and snack foods/sweets.

Keywords
Neighbourhood
Resources
Children
Diet
Environment

The number of meals and snacks including beverages consumed by children and adolescents has increased over the past few decades[1,2] from approximately three per day in 1977 to five per day in 2006[1]. During this time, children's (ages 2–18 years) daily energy intake has increased by ~770 kJ (184 kcal), which may be partially attributed to greater consumption of sugar-sweetened beverages (SSB) and energy-dense foods[3]. The local food environment, areas surrounding children's homes and schools, may play an important role in shaping children's dietary behaviours by providing easy access to energy-dense food items and beverages. In a recent study of children's (grades 4–6) purchasing behaviours at urban corner stores, it was reported that, on average, children spent $US 1·07 on approximately two items that contained 1494 kJ (357 kcal). The most frequently purchased items were those with low nutritional value, such as chips, candy and SSB[4].

Previous research has examined the influence of the local food environment on children's dietary intakes and behaviours, especially within schools[5]; a smaller number of studies have focused on the influence of local food environments. Close proximity of homes and/or schools to convenience stores and other food outlets, as assessed by objective geographic measurements, is associated with SSB intake[6–8], low scores on a modified Healthy Eating Index[9] and greater likelihood of eating/snacking outside the home[8]. However, null associations of these measures and intakes of fruits and vegetables, high-sugar foods and fast foods are also reported[6,10]. Results from studies using subjective measures are also mixed. Reported use of

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fast-food restaurants[11] and shorter perceived walking time from home to food retail outlets[7] are positively associated with SSB purchases, but there is no association for walking time and purchases of convenience store foods or fast foods[7].

There is a continued need to understand the role of the local food environment in shaping dietary intakes, especially in young children. We used data collected from a multi-site (New York, Cincinnati and the San Francisco Bay area) observational cohort study of girls of elementary-school age to describe the availability and frequency of use of local snack-food outlets (convenience stores, fast-food outlets and food stands) en route from home to school. We also determined whether reported use of these outlets was associated with daily intakes of energy, SSB and snack foods/sweets. The study provides unique information regarding the potential influence of the local food environment on the dietary intakes of young children living across the USA.

Methods

Data were collected as part of The Puberty Study of the Breast Cancer and Environment Research Program conducted by the National Institute of Environmental Health Sciences (NIEHS) and National Cancer Institute (NCI) Breast Cancer and the Environment Research Centers (BCERC). The primary objective of the programme is to investigate environmental exposures and onset of puberty in girls. Data collection occurred at three sites: (i) Mount Sinai School of Medicine (MSSM), which recruited in East Harlem, New York (New York); (ii) Cincinnati Children's Hospital/University of Cincinnati (Cincinnati), which recruited in the Cincinnati metropolitan area and the Breast Cancer Registry of Greater Cincinnati; and (iii) the Kaiser Permanente Northern California (KPNC)/University of California at San Francisco group, which recruited in the San Francisco Bay area (Bay Area). A description of the study and recruitment process is presented elsewhere[12]. The study was approved by the institutional review board at each site and the Centers for Disease Control and Prevention. A total of 1239 girls, aged 6 to 8 years, were enrolled and had baseline (Year 1) data collected during 2004–2006. There were 1024 (82·6 %) girls with Year 2 data. All data were collected via interviewer-administered questionnaires (conducted in English or Spanish) or self-administered mailed questionnaires that were completed by a parent or guardian of the child.

Dietary assessment

Information on the child's diet was ascertained from interviewer-administered 24 h dietary recalls using the Nutrition Data System for Research (NDSR) software version 2010 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, USA). All recalls were completed by the child's parent or guardian. Approximately four 24 h recalls were obtained during Year 1; four recalls are intended to provide average intakes for the year by including daily and seasonal variation in foods consumed. There were thirteen girls with no dietary recall data. In other cases, all four dietary recalls were not obtained or dietary recalls were considered incomplete due to inconsistent reported daily energy intakes of < 2092 kJ (n 23) or > 20 920 kJ (n 1). All girls had at least two completed recalls and 86 % had all four completed recalls. Dietary intake data were averaged across the total number of completed recalls for each girl. The average daily intakes of the following dietary variables (nutrients and food/beverage groups) were considered in analyses: energy (kJ) and servings of SSB and snack foods/sweets. SSB included all non-diet sweetened fruit drinks (excluding 100 % juice), iced teas and sodas; snack foods included crackers, popcorn, chips, fried potatoes and snack bars; and sweets included cakes, frozen desserts, chocolate candy, non-chocolate candy and miscellaneous desserts.

Local food environment

Three types of local snack-food outlets were included: (i) food stands (such as ice cream trucks, hot dog stands or newsstands); (ii) convenience stores; and (iii) fast-food outlets. Availability of outlets was assessed with a yes/no response to the following question on the Year 2 questionnaire: 'Are there [food outlet] present outside [child's name]'s school or on the way home from school?' If the response was 'yes', then frequency of use of food outlets was assessed by the following question: 'During a usual week or month, how many times does [child's name] eat foods/drinks purchased from [food outlet]?' Frequency of use responses were calculated as number of times per week. Local snack-food outlet availability was categorized as the reported number of types of available outlets: none (no types of outlets were available); one type of outlet (one of the three types of outlets was available); two types of outlets (two of the three types of outlets were available); and three types of outlets (all three types of outlets were available). Among those who reported having at least one type of local snack-food outlet available and who responded to the frequency of use question, weekly frequency of use was categorized as none, > 0 to 1, >1 to 3 and >3 times/week. Responses of 'don't know' for snack-food outlet availability (n 9) or frequency of use (n 7) were coded as 'none'.

Sociodemographic variables

Sociodemographic data were collected at baseline using interviewer-administered questionnaires. Data included highest level of education attained by the child's parent/guardian, annual household income, child's race/ethnicity and child's age in years at enrolment. Household income was reported as a choice of specific income ranges (as displayed in Table 1) or broader income categories: > $US 25 000 ($n$ 5), > $US 50 000 ($n$ 6) and > $US 75 000 ($n$ 4).

Participants who reported one of the broader income categories were placed within a specific range based on the lower cut-point of the range. For example, participants who reported a household income > $US 25 000 were categorized with those who reported a household income of $US 25 000–50 000. Race/ethnicity was identified as black, white, Hispanic and Asian.

Statistical analysis

All statistical analyses were conducted using the statistical software program Stata version 11·0. Descriptive statistics included frequencies, means and standard deviations for the total population and stratified by site. Multivariable linear regression models were used to estimate the average differences in the daily intakes of selected dietary variables (energy, servings of SSB and servings of snack foods and sweets) associated with categories of weekly frequency of use of local snack-food outlets. A statistical interaction by site was tested. Interaction terms were added in each model to determine whether associations between frequency of use of snack-food outlets and dietary intakes varied by site. None were statistically significant ($P > 0{\cdot}10$); therefore, analyses using the entire sample are presented. Final models were adjusted for race/ethnicity and education. Additional adjustment for age and household income did not appreciably change the magnitude of the effect estimates; therefore, these variables were not included in models. Random-effects models were also examined to adjust for a potential clustering by site. Results from these models did not substantially differ from those using linear regression and are not presented.

Results

Of the 1024 girls who participated in Years 1 and 2, 1010 (98·6 %) had data available and were included in the final analytic sample. Distributions of sociodemographic characteristics of the study population (total and stratified by site) are displayed in Table 1. Overall, girls in New York were more likely to be black or Hispanic and have less education and lower household income compared with participants in Cincinnati and the Bay Area. Differences in the distributions of the local snack-food outlet variables across the sites were apparent (Table 2). Girls in New York were more likely to report available local outlets compared with those in Cincinnati and the Bay Area. Nearly half of girls in New York had all three types of local snack-food outlets (food stands, convenience stores and fast-food places) compared with 11·5 % and 12·5 % of girls in Cincinnati and the Bay Area, respectively. Convenience stores were the most frequently reported available type of local snack-food outlet at all three sites.

Among all girls with at least one available type of local snack-food outlet (*n* 747), 74·7 % reported consuming food/beverage items, of whom 24·2 % reported a frequency of use of >3 times/week. In New York, 86·4 % of girls reported using local outlets, of whom almost half reported consuming items >3 times/week. This compares with Cincinnati where 77·8 % reported using local outlets, of whom 17·7 % reported a frequency of use of >3 times/week and the Bay Area where 60·2 % reported local outlet use, of whom 5·6 % reported a frequency of use of > 3 times/week. Girls in Cincinnati and the Bay Area were more likely to report consuming items from fast-food

Table 1 Baseline sociodemographic characteristics of participants in the Breast Cancer and the Environment Research Centers (BCERC) study, total and stratified by site (*n* 1010)

	Total		New York		Cincinnati		Bay Area	
Characteristic	*n*	%	*n*	%	*n*	%	*n*	%
Age (years)	1010		296		305		409	
6–7	373	37	124	42	135	44	114	28
> 7–8	535	53	92	31	151	50	292	71
> 8–9	102	10	80	27	19	6	3	1
Race/ethnicity	1010		296		305		409	
Black	294	29	115	39	95	31	84	21
Hispanic	288	29	181	61	9	3	98	24
Asian	54	5	0	0	4	1	50	12
White	374	37	0	0	197	65	177	43
Caregiver education level	992		289		297		406	
< Grade 12	161	16	105	36	28	9	28	7
High-school graduate	327	33	124	43	73	25	130	32
Associate/bachelor's degree	336	34	50	17	127	43	159	39
Master's degree or higher	168	17	10	4	69	23	89	22
Household income	982		276		304		402	
≤ $US 25 000	212	22	156	56	40	13	16	4
> $US 25 000–50 000	198	20	83	30	55	18	60	15
> $US 50 000–75 000	164	17	25	9	75	25	64	16
> $US 75 000–100 000	134	14	10	4	43	14	81	20
> $US 100 000	274	28	2	1	91	30	181	45

Table 2 Distributions of availability of types of local snack-food outlets (food stands, convenience stores and fast-food places) and weekly frequency of use of these outlets among participants in the Breast Cancer and the Environment Research Centers (BCERC) study, total and stratified by site (*n* 1010)

	Total		New York		Cincinnati		Bay Area		
	n	%	*n*	%	*n*	%	*n*	%	*P**
Availability of local snack-food outlets†									
Number of types of local snack-food outlets available	1010		296		305		409		
None	259	26	14	5	105	34	140	34	<0·001
One type of outlet	241	24	43	15	71	23	127	31	
Two types of outlets	289	29	104	35	94	31	91	22	
All three types of outlets	221	22	135	46	35	12	51	13	
Local food stands available	1010		296		305		409		
Yes	428	42	225	76	57	19	146	36	<0·001
Local convenience stores available	1010		296		305		409		
Yes	611	61	253	86	167	55	191	47	<0·001
Local fast-food places available	1010		296		305		409		
Yes	443	44	178	60	140	46	125	31	<0·001
Frequency of use of local snack-food outlets‡									
Weekly frequency of use of local snack-food outlets	747		280		198		269		
No use	189	25	38	14	44	22	107	40	<0·001
>0 to 1 times/week	185	25	39	14	61	31	85	32	
>1 to 3 times/week	192	26	72	26	58	29	62	23	
>3 times/week	181	24	131	47	35	18	15	6	
Weekly frequency of use of local food stands	426		223		57		146		
No use	145	34	48	22	24	42	73	50	<0·001
>0 to 1 times/week	131	31	57	26	24	42	50	34	
>1 times/week	150	35	118	53	9	16	23	16	
Weekly frequency of use of local convenience stores	606		250		165		191		
No use	231	38	64	26	52	32	115	60	<0·001
>0 to 1 times/week	173	29	53	21	70	42	50	26	
>1 times/week	202	33	133	53	43	26	26	14	
Weekly frequency of use of local fast-food places	438		176		138		124		
No use	176	40	97	55	31	23	48	39	<0·001
>0 to 1 times/week	187	43	60	34	63	46	64	52	
>1 times/week	75	17	19	11	44	32	12	10	

*P value from χ^2 test for differences across sites.
†Availability of local snack-food outlets was defined as the reported presence of a food outlet outside of the child's school or on the way home from school.
‡Frequency of use was defined as the reported number of purchases per week from a local snack-food outlet. The sample includes only those participants who reported having food outlets available and who responded to the question (*n* 747).

places while those in New York were more likely to report consuming items from food stands and convenience stores (Table 2).

Availability of local snack-food outlets and weekly frequency of use

Girls' weekly frequency of use of local snack-food outlets increased with the number (one, two or three) of available types of outlets (Table 3). Among all girls, the average weekly frequencies of use were 0·88 times/week for those with one type of outlet, 2·27 times/week for those with two types of outlets and 3·45 times/week for those with all three types of outlets. Only 4·6 % of girls with one type of local snack-food outlet reported consuming items >3 times/week compared with 25·4 % and 43·9 % of those with two types and all three types of local outlets, respectively. Average weekly frequencies of use were greatest for participants in New York, ranging from 1·39 times/week for those with one available outlet to 4·39 times/week for those with all three outlet types. Among girls with all three local outlet types, 58·5 % of those in New York reported consuming items >3 times/week compared with 34·3 % and 11·8 % of girls in Cincinnati and the Bay Area, respectively.

Dietary intakes and weekly frequency of use of local snack-food outlets

Linear regression models showing the average change in daily energy (kJ) and daily servings of SSB and snack foods/sweets associated with weekly frequency of use of local snack-food outlets are shown in Table 4. Girls' energy, SSB and snack foods/sweets intakes increased across categories of weekly frequency of use of local outlets and statistically significant differences were observed. Specifically, girls who reported using outlets >1 to 3 times/week consumed an average of 0·27 (95 % CI 0·13, 0·40) daily servings of SSB more than participants who reported no use of outlets. Girls who reported using outlets >3 times/week consumed an average of 449·61 (95 % CI 134·93, 764·29) kJ, 0·43 (95 % CI 0·29, 0·58) servings of SSB and 0·38 (95 % CI 0·12, 0·65) servings of snack foods/sweets more daily than girls who reported no weekly use of local snack-food outlets. All other associations between local snack-food outlet use and dietary intakes were not statistically significant (P > 0·05).

Table 3 Categories of weekly frequency of use of local snack-food outlets by reported number of available outlets for participants in the Breast Cancer and the Environment Research Centers (BCERC) study, total and stratified by site (*n* 747)

	Total (*n* 747)		New York (*n* 280)		Cincinnati (*n* 198)		Bay Area (*n* 269)		
Weekly frequency of use	*n*	%	*n*	%	*n*	%	*n*	%	*P**
One available local snack-food outlet									
No use	108	45	17	42	19	27	72	57	< 0·001
> 0 to 1 times/week	72	30	10	24	30	43	32	25	
> 1 to 3 times/week	47	20	8	20	17	24	22	17	
> 3 times/week	11	5	6	15	4	6	1	1	
Two available local snack-food outlets									
No use	58	20	15	14	18	19	25	28	< 0·001
> 0 to 1 times/week	75	26	15	14	24	26	36	40	
> 1 to 3 times/week	82	29	28	27	32	34	22	24	
> 3 times/week	73	25	46	44	19	20	8	9	
Three available local snack-food outlets									
No use	23	10	6	4	7	20	10	20	< 0·001
> 0 to 1 times/week	38	17	14	10	7	20	17	33	
> 1 to 3 times/week	63	29	36	27	9	26	18	35	
> 3 times/week	97	44	79	59	12	34	6	12	

*P value from χ^2 test for differences across sites.

Table 4 Unadjusted and adjusted* linear regression models of selected daily dietary intakes and categories of weekly frequency of use of local snack-food outlets among participants in the Breast Cancer and the Environment Research Centers (BCERC) study

	Unadjusted model (*n* 747)			Adjusted model (*n* 734)		
	B†	95 % CI	*P*	*B*	95 % CI	*P*
Energy (kJ)						
No use of local snack-food resources	–	Referent	–	–	Referent	–
> 0 to 1 times/week	− 75·56	− 378·74, 227·61	0·63	− 4·23	− 294·14, 285·64	0·98
> 1 to 3 times/week	80·67	− 219·70, 381·04	0·60	261·17	− 33·47, 556·05	0·08
> 3 times/week	173·76	− 131·13, 478·61	0·26	449·61	134·93, 764·29	0·005
Sugar-sweetened beverages (servings/d)						
No use of local snack-food resources	–	Referent	–	–	Referent	–
> 0 to 1 times/week	0·17	0·03, 0·30	0·02	0·16	0·03, 0·29	0·02
> 1 to 3 times/week	0·3	0·17, 0·43	< 0·001	0·27	0·13, 0·40	< 0·001
> 3 times/week	0·48	0·35, 0·62	< 0·001	0·43	0·29, 0·58	< 0·001
Snack foods and sweets (servings/d)						
No use of local snack-food resources	–	Referent	–	–	Referent	–
> 0 to 1 times/week	− 0·16	− 0·43, 0·10	0·23	− 0·06	− 0·31, 0·18	0·62
> 1 to 3 times/week	− 0·08	− 0·34, 0·19	0·57	0·19	− 0·06, 0·44	0·14
> 3 times/week	− 0·08	− 0·35, 0·19	0·55	0·38	0·12, 0·65	0·01

Sugar-sweetened beverages: all non-artificially sweetened fruit juices (excludes 100 % juice), soda and iced tea.
Snack foods and sweets: chips, crackers, popcorn, fried potatoes, snack bars, non-chocolate candy, chocolate, cakes, frozen desserts and miscellaneous desserts.
*Adjusted model includes race and education.
†*B* coefficients represent the average change in the selected dietary characteristic associated with the category of local food environment variable (i.e. number of resources or weekly frequency of use of resources) compared with the reference (none).

Discussion

In the current study we used subjective measures to describe the local food environment of a multi-ethnic sample of girls of elementary-school age in three diverse regions of the USA. Use of local snack-food outlets was greater when more outlets were reported available. Across all three study sites, girls with access to only one type of local snack-food outlet consumed fewer food/beverage items than those with access to two or three types of outlets. Girls who used local snack-food outlets had higher average daily intakes of energy and servings of SSB and snack foods/sweets. Compared with girls who did not use local outlets, those who used outlets >1 to 3 times/week consumed an excess of nearly one-third of a serving of SSB daily and those who used outlets >3 times/week consumed an excess of 449 kJ daily and over one-third of a serving of both SSB and snack foods/sweets daily.

Adverse influence of the local food environment and SSB has been reported previously. In studies of children, SSB intakes/purchases increased with the number of weekly visits to fast-food restaurants[11] and shorter walking distance from home to a food outlet, especially convenience stores and fast-food restaurants[7]. SSB intakes were also associated with school[8] or residential[6] proximity (measured using a Geographic Information System) to various food outlets;

regression estimates for increases in SSB consumption ranged from 0·23 to 0·31 servings/d[6]. Although these findings are mostly among older children (~11–18 years of age), these estimates are similar to the average increases in daily servings of SSB associated with frequency of use of snack-food outlets reported here.

Evidence in the published literature supporting an association of the local food environment and other aspects of children's diets is inconsistent. We found positive associations for weekly frequency of use of local snack-food outlets and participants' intakes of energy and snack foods/sweets. He *et al*. reported lower diet quality scores among children (aged 11–14 years) with convenience stores and fast-food outlets located < 1 km from their homes and/or schools[9]. Similarly, Van Hulst *et al*.[8] found higher intakes of fruits and vegetables among children (aged 6–8 years) living in or attending a school in neighbourhoods with low densities of fast-food restaurants. However, other studies observed no associations of objective measures of school and residential food environments and dietary intakes, including energy, fruits, vegetables, juice, milk, soda, high-sugar foods and fast foods, as well as fast food and convenience store purchases[6,7,10]. Discrepancies in findings across studies may be due to differing measures (objective or subjective) and definitions of the local food environment (counts or densities of food outlets and proximity to home and/or school), as well as dietary assessment methods[13]. Children's diets may be assessed by surveys or more comprehensive tools and capture purchasing/consumption behaviours or absolute dietary intakes. We found that children who used snack-food outlets > 3 times/week consumed an additional 449 kJ/d, which is consistent with the greater daily servings of SSB and snack foods/sweets among these children. This additional energy intake is sizeable for this age group (the recommended daily energy intake for girls aged 4–8 years is 5021 kJ[14]) and could lead to weight gain if not compensated by increased energy expenditure; positive associations between the availability of convenience stores and fast-food outlets and children's BMI status have been reported previously[15–17].

The major strengths of the present study are that it was conducted in a multi-ethnic and multi-geographic population of girls of elementary-school age and it included a comprehensive assessment of their dietary intakes. However, the results must be interpreted with consideration for the study's limitations. First, dietary intakes were based on caregivers' report, which may not accurately measure children's behaviours in the absence of their caregivers and may underestimate dietary intakes and snack purchasing behaviours. Additionally, definitions of the local food environment were based on subjective measures – the caregivers' reported availability and frequency of use of types of food outlets located near or on the way home from school; therefore, food outlets were not linked to specific locations. Second, we lacked data on actual food/beverage purchases. Positive associations of frequency of local snack-food outlet use and the selected dietary intakes may be due to poor diet choices in general among individuals who use food outlets and not due to actual purchases at those outlets. Third, the study population was limited to girls, so we cannot comment on whether these associations would be found in boys; however, other studies have not reported gender differences. Lastly, data were cross-sectional and cannot be used to infer causality.

Conclusions

Results from the current study and previous studies suggest that children's frequency of use of local snack-food outlets increases with the number of available types of outlets[7,11]. We found that frequency of use of local outlets >1 time/week is associated with greater intakes of SSB and frequency of use >3 times/week is associated with greater energy and snack foods/sweets intakes. Although the energy contribution of beverages to children's diets has remained constant over the past few decades, consumption of SSB continues to replace consumption of nutritional beverages[18]. This has important health implications because children do not adjust their dietary intakes to compensate for energy from beverages[19] and SSB are linked to paediatric obesity[20]. Prospective research that includes specific information on children's purchases and intakes is required to determine how the food environment influences children's diets and whether it has a lasting impact on dietary behaviours and health outcomes.

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