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ORIGINAL ARTICLE

School environment and policies, child eating behavior and overweight/obesity in urban China: the childhood obesity study in China megacities

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OBJECTIVES: Childhood obesity is rising rapidly in China, especially in urban areas. Knowledge about how school environment and policies (SEPs) may have contributed to the epidemic remains limited. We examined SEP and their associations with students' eating behaviors and overweight/obesity in urban China.

METHODS: Data were collected from 1648 students (plus their parents and schools) in 16 primary and middle schools (4 schools per city) in four megacities across China: Beijing, Shanghai, Nanjing and Xi'an. We examined nutrition-related SEP such as unhealthy food restriction, healthy food promotion, price control and nutrition guideline in school cafeterias (SCs), campus food stores (CFS), school vicinity food stalls (SVFS); SEP on physical activity, physical education (PE) and physical examination. Cluster robust regression models were fit to assess associations of SEP with child eating behaviors and overweight/obesity (defined based on body mass index, from measured weight and height).

RESULTS: All 16 schools had regular PE classes and annual physical examination. Most schools ($n = 12$; 75%) had food policies in SC; few had policies on CFS ($n = 1$; 6.25%) or SVFS ($n = 4$; 25%). Local governments had a major role in regulating food prices, setting nutrition guidelines and regulating SVFS. Policies on CFS and SVFS were associated with less frequent intake of sugary beverage (odds ratio (OR) = 0.54 (0.47–0.61); OR = 0.70 (0.61–0.80)), snack (OR = 0.84 (0.74–0.95); OR = 0.78 (0.67–0.92)) and fast food (OR = 0.58 (0.42–0.81); OR = 0.56 (0.39–0.80)). The associations were stronger for boys. Policies on SC, CFS and SVFS were associated with lower likelihood for overweight/obesity (OR = 0.60 (0.46–0.79); OR = 0.74 (0.62–0.90); OR = 0.51 (0.35–0.73)) and central obesity (OR = 0.79 (0.70–0.89); OR = 0.67 (0.48–0.92); OR = 0.63 (0.48–0.84)) in boys. Policies on SC were associated with lower overweight/obesity odds (OR = 0.48 (0.28–0.82)) for girls.

CONCLUSIONS: SEP are heterogeneous in the four Chinese megacities, high-income areas. They affect child unhealthy eating and overweight/obesity, and are critical for fighting childhood obesity in China.

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INTRODUCTION

Childhood obesity has become a serious public health concern in many countries including China.[1–3] Effective interventions are urgently needed. Recently the World Health Organization (WHO) called on nations to take actions including national policies to end the epidemic.[4]

School is an important locale with an array of factors that may affect obesity risk of children.[5–8] School unhealthy food restrictions were associated with children's healthier food intake and lower risk of obesity,[9–11] while school environment and policies (SEPs) facilitating unhealthy food access may increase energy intake.[12] School physical education (PE),[13] physical activity (PA) facilities[14] and breaks during school hours[14,15] were all associated with children's more PA and lower risks of overweight/obesity. Intervention studies have shown that well designed and successfully implemented school-based interventions can effectively improve children's diet quality, promote PA and reduce their sedentary behaviors.[16–18] Successful school-based interventions need to be developed based on solid evidence on school-level risk and protective factors for the development of obesity, which remains inadequate in most developing countries.

As the largest developing country in the world, China has seen a marked growth of childhood overweight/obesity over the past two decades.[19,20] Particularly in urban China, increased availability of modern conveniences (for example, motorized transportation, TV, computer, internet, etc.) and access to Western-style food have contributed to the rising epidemic of overweight and obesity:[21,22] today, the combined prevalence of childhood overweight/obesity in urban China has more than doubled over the past two decades, reaching ~30% for boys and 16% for girls.[23,24] A close examination of school risk/protective factors for childhood obesity in urban China is critical for fighting the epidemic, given that the country is under rapid urbanization and most future population growth is expected to occur in urban areas.

Nevertheless, it remains unclear how school policies are currently implemented in urban China and how they may influence children's eating behaviors and weight outcomes. Moreover, a study suggested that school environment tend to

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have different impacts on boys and girls.[25] Research is thus warranted to examine gender disparities in the school policy impacts on child eating and weight status.

Using data recently collected from four megacities (population >8 million in each city) in China, this study aimed to: (1) examine the current status of energy-balance-related SEPs in high-income areas in China; (2) assess associations of SEPs with students' eating behaviors and weight outcomes; and (3) examine potential gender variations in these associations. Findings of this study will help inform future childhood obesity interventions in the urban setting of developing countries.

MATERIALS AND METHODS

Study design and participants

The study was based on the baseline data of the Childhood Obesity Study in China Megacities (COCM) that was collected in 2015. The COCM sampled 1648 students from 16 schools in four Chinese megacities (geographical locations displayed in Figure 1): Beijing (China's capital city, North China), Shanghai (the largest city in China, East China), Nanjing (China's capital city before 1949, East China) and Xi'an (the largest city in West China). In each city, two primary schools and two middle schools were randomly selected, where one class was randomly selected from the 3rd to the 6th grades of each primary school and one from the 7th to the 9th grades of each middle school. All students in the selected classes and their mothers (or other primary care givers if mothers were absent) were interviewed. Data collected included child growth and health, family characteristics, home/community/school environment and energy-balance-related behaviors. School information was provided by school administrators, school doctors and PE teachers. The study was approved by the Ethical Committee of the State University of New York at Buffalo and related collaboration institutes in China. Written informed consent was obtained from parents or children.

Observations with missing data on any individual- or school-level variables were excluded (that is, list-wise deletion). The final analytic sample size for the associations was thus 1457 students (missing rate = 12%).

Variables and measurements

Outcomes

Body mass index: Students' body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Height was measured by trained health professionals using Seca 213 Portable Stadiometer Height-Rods (Seca China, Zhejiang, China) with a precision of 0.1 cm; body weight was measured using Seca 877 electronic flat scales (Seca China, Zhejiang, China) with a precision of 0.1 kg and waist circumference was measured using an inflexible tape with a precision of 0.1 cm.

Weight status: Overweight was defined based on the International Obesity Task Force-recommended age- and sex-specific cutoffs corresponding to BMI = 25 kg m^{-2} at age 18 years.[26] Obesity was defined based on the International Obesity Task Force-recommended age- and sex-specific cutoffs corresponding to BMI = 3025 kg m^{-2} at age 18 years.

Central obesity was defined as a waist circumference ⩾ age-sex-specific 90th percentile based on data of 65 898 school-aged children (7–18 years old) from nine national studies in China,[27] given that international references for central obesity are not available.

Students' eating behaviors: Students' eating behaviors included self-reported weekly frequency of sugary beverage, snack, fast food and street food consumption. The original questions asked were 'On average, how many times per week did you drink sugary beverages/eat snacks/eat at Western-style fast food restaurants/eat at street food stalls in the last 3 months?'

Exposure variables: SEP factors

School policies: A dummy variable was constructed for each of the following school policies: food regulations in school cafeterias (SCs), food regulations in campus food stores (CFS), food regulations in school vicinity food stalls (SVFS), school PE classes, extracurricular PA requirement and school physical examination. For each dummy variable, '1' represents the presence of respective policy and '0' otherwise. School policy information was reported by school administrators.

Types of school food regulations: For schools having food regulations in SC, CFS or SVFS, school administrators were asked to report the types of regulation: unhealthy food restrictions, healthy food promotion,

Figure 1. Four Chinese megacities from which 1648 students were sampled in the COCMs in October 2015: Beijing, Shanghai, Nanjing and Xi'an.

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price monitor/control or setting nutrition guidelines. A school can have multiple types of food regulations.

School food regulators: Regarding each type of food regulation, school administrators were asked to report who placed the regulation (school and/or local government).

SC utilization: Utilization of SC was measured as the school mean of students' self-report weekly frequency of eating at SC.

SC popularity: Popularity of SC was measured as the school proportion of students who reported liking SC.

Covariates. Covariates included age (in years), father's and mother's BMI (kg m^{-2}, calculated from self-reported body weight and height), parental highest education ('middle school or lower', 'high school or vocational school', 'college or above'), family home ownership ('rent or living with relatives', 'own an apartment' and 'own a house') and student pocket money (in Chinese *yuan*, categorized into '0', '1–10', '>10–30' and '>30' *yuan*; according to the exchange rate at the time of the survey, one Chinese *yuan* was ~0.15 US$).

Statistical analysis

First, χ^2 tests (for categorical variables) and *t*-tests (for continuous variables) were conducted to identify significant gender disparities in obesity status, eating behaviors and other characteristics. Second, we examined the current patterns of SEPs (that is, percentage of schools with certain policies).

Third, to examine associations between SEPs and students' eating behaviors, we used negative binomial regressions with cluster robust standard errors, given the nested data structure (that is, students in schools) and that these outcomes were count variables displaying overdispersion. Similarly, we used cluster robust logistic regression to model binary weight status variables (that is, overweight/obesity and central obesity), where we included school extracurricular PA requirement as an additional predictor. We also fitted separate models by gender to examine potential gender difference in these associations. All analyses were performed using Stata 14 (StataCorp, College Station, TX, USA).[28]

RESULTS

Sample characteristics

Characteristics of 1457 students were shown in Table 1. The combined prevalence of overweight/obesity and prevalence of central obesity were 25.6% and 21.5%, respectively. Boys were more likely to be overweight or obese than girls (prevalence of overweight/obesity 32.8 vs 18.1%, $P < 0.001$; prevalence of central obesity; 25.2 vs 17.6%, $P < 0.001$), and were more frequent consumers of sugary beverage (10 vs 8 times per week, $P < 0.001$), fast food (0.7 vs 0.6 times per week, $P < 0.05$) and street foods (1.53 vs 1.24 times per week, $P < 0.01$). No gender differences were found in snaking consumption.

School environment and policies

As was shown in Table 2, most schools (62.5–75%) had one or more types of food regulation in SC in the form of unhealthy food restriction, healthy food promotion, price monitor/control and/or nutrition guidelines. Local governments are more likely to play roles in setting SC price control (56.3 vs 37.5%) and nutrition guidelines (56.3 vs 25%) than school administrations.

Only one school (6.3%) had food regulations on CFS, which had simultaneously implemented three types of regulations: unhealthy food restriction, food price monitor/control and setting nutrition guidelines. All regulations were from both the local government and the school administration.

Four schools (25%) had food regulations on SVFS, among which all had policies restricting unhealthy food provision, three (18.8%) had policies promoting healthy food provision, two (12.5%) had food price policies and two (12.5%) had nutrition guidelines. We also found that, in three out of four schools, polices on SVFS were from local governments, rather than school administrations.

All schools had policies regarding PE classes and physical examination. However, school PE classes were more likely to be a local government policy (93.8%) than a school policy (56.3%). Fourteen schools (87.5%) had extracurricular PA requirement. Extracurricular PA requirement was more often from school administrations (56.3%) than from local governments (43.8%). All schools had physical examination for students. School physical examination was more likely to be a local government policy (100%) than a school policy (62.5%).

Associations between SEP and students' eating behaviors

Table 3 shows that food regulations on CFS and/or SVFS were associated with lower frequencies of sugary beverage (incident rate ratio (IRR) = 0.54, 95% confidence interval (CI) = 0.47–0.61 and IRR = 0.70, 95% CI = 0.61–0.80, respectively), snack (IRR = 0.84, 95% CI = 0.74–0.95 and IRR = 0.78, 95% CI = 0.67–0.92, respectively), and fast food consumptions (IRR = 0.58, 95% CI = 0.42–0.81 and IRR = 0.56, 95% CI = 0.39–0.80, respectively). Gender-stratified analyses showed that, for girls, fast food consumption was not significantly associated with CFS and SVFS policies, neither was snack consumption with CFS policies.

Interestingly, SC policies were associated with more frequent snack consumption for boys (IRR = 1.20, 95% CI = 1.03–1.40), and more frequent fast food consumption for girls (IRR = 1.30, 95% CI = 1.08–1.57). Policies on SVFS were associated with higher frequency of street food consumption (IRR = 1.61, 95% CI = 1.26–2.07). No significant associations were found between SC utilization or popularity and students' eating behaviors.

Associations between SEP and students' weight status

Food policies on SC were associated with lower odds of overweight/obesity (OR = 0.54, 95% CI = 0.39–0.75) among all students (Table 4), and lower odds of central obesity for boys (OR = 0.79, 95% CI = 0.70–0.89). Policies on SVFS were associated with reduced odds of overweight/obesity (OR = 0.56, 95% CI = 0.35–0.89) and central obesity (OR = 0.61, 95% CI = 0.45–0.83), especially among boys. Policies on CFS were associated with lower odds of overweight/obesity (OR = 0.74, 95% CI = 0.62–0.90) and central obesity (OR = 0.67, 95% CI = 0.48–0.92) only for boys. SC utilization was negatively associated with odds of overweight/obesity for boys (OR = 0.91, 95% CI = 0.84–0.99). No significant associations existed between school extracurricular PA requirement and students' weight status.

DISCUSSION

This is the first study examining SEPs and students' eating behaviors and weight status in Chinese megacities, which have witnessed rapid economic development over the past two to three decades and are at the forefront of the nutrition transition and thus bear heavy obesity burdens.[23,29] Our analyses focused on four types of school food policies—unhealthy food restriction, healthy food promotion, price monitor/control and nutrition guidelines—at three locales: SC, CFS and SVFS. We also examined PA-related SEP and school physical examination.

We found more variations in school food policies than in PA-related policies. All 16 schools in our study had regular PE classes and physical examination, and most schools ($n = 14$) had extracurricular PA requirement. As for food policies, even though most schools ($n = 12$; 75%) had certain type of regulations in SC, only one had regulations on CFS and a few had regulations on SVFS ($n = 4$; 25%).

School administrations and local governments played different roles in regulating school food environment. Local governments were the major agency controlling food prices and setting nutrition guidelines at all locales. Particularly, almost all polices on SVFS were from local governments. School administrations were important regulators on SC, particularly regarding unhealthy

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food restriction and healthy food promotion. However, regulations from school administrations on CFS and SVFS were rarely seen, a fact suggesting that school administrations may have limited power in affecting off-campus food environment through policy leverage.

We found that policies on CFS and SVFS were associated with less frequent intakes of sugary beverage, snack and fast food among students, especially for boys. Consistently, all school food policies were associated with lower risks of overweight/obesity and central obesity, especially for boys. Girls' weight status was

Table 1. Characteristics of sample students ($n = 1457$) in four megacities in China, Childhood Obesity Study in China Megacities, 2015

	All (n = *1457*)	*Boys* (n = *738*)	*Girls* (n = *719*)	P-*value*[a]
	Mean ± s.d. or %	*Mean ± s.d. or %*	*Mean ± s.d. or %*	
Child outcome variables				
Overweight and obesity[b]	25.6	32.8	18.1	< **0.001**
⩾90th percentile of waist circumference	21.5	25.2	17.6	< **0.001**
Sugary beverage (in times per week)	9.0 ± 9.3	9.9 ± 10.2	8.0 ± 8.1	< **0.001**
Snack (in times per week)	12.3 ± 11.2	12.3 ± 11.6	12.4 ± 10.7	0.843
Fast food (in times per week)	0.6 ± 1.0	0.7 ± 1.1	0.6 ± 1.9	**0.019**
Street food stalls (in times per week)	1.40 ± 1.88	1.53 ± 2.03	1.24 ± 1.66	**0.002**
Covariates				
Age (in years)	11.6 ± 2.0	11.6 ± 2.0	11.6 ± 2.1	0.966
Father's BMI (in kg m^{-2})	24.3 ± 3.2	24.4 ± 3.3	24.2 ± 3.0	0.505
Mother's BMI (in kg m^{-2})	22.1 ± 3.2	21.9 ± 2.8	22.4 ± 3.5	< **0.001**
Parental highest education level				
Middle school or below	16.6	19.4	13.8	
High or vocational schools	29.7	30.5	28.8	**0.003**
College or above	53.5	50.1	57.5	
Family living condition				
Rent or living with relatives	33.1	34.8	31.4	
Own apartment	58.9	57.2	60.6	0.348
Own house	8.0	8.0	8.0	
Child pocket money per week (in yuan[c])				
0	30.9	32.4	29.3	
1–10	28.2	26.6	29.8	0.280
10–30	20.5	21.4	19.6	
30+	20.4	19.6	21.3	

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force. Numbers in bold indicate statistical significance. [a]*P*-values were based on χ^2 tests for categorical variables or *t*-tests for continuous variables across genders. [b]Overweight and obesity were defined based on the IOTF-recommended age- and sex-specific cutoffs corresponding to BMI ⩾ 25 and 30 kg m^{-2} at age 18 years, respectively. [c]Yuan is Chinese monetary unit.

Table 2. School policy and environmental factors among 16 schools in four megacities in China, Childhood Obesity Study in China Megacities, 2015

	Number (%)/mean ± s.d.	*Who made policies*	
		School	*Government*
School cafeteria food policy (yes/no)	12 (75.0)	11 (68.8)	11 (68.8)
Unhealthy food restriction	12 (75.0)	8 (50.0)	11 (68.8)
Healthy food promotion	12 (75.0)	9 (56.3)	8 (50.0)
Food price monitor/control	10 (62.5)	6 (37.5)	9 (56.3)
Having nutrition guidelines	10 (62.5)	4 (25.0)	9 (56.3)
Campus food store policy (yes/no)	1 (6.3)	1 (6.3)	1 (6.3)
Unhealthy food restriction	1 (6.3)	1 (6.3)	1 (6.3)
Healthy food promotion	0 (0.0)	0 (0.0)	0 (0.0)
Food price monitor/control	1 (6.3)	1 (6.3)	1 (6.3)
Having nutrition guidelines	1 (6.3)	1 (6.3)	1 (6.3)
School vicinity food stall policy (yes/no)	4 (25.0)	1 (6.3)	3 (18.8)
Unhealthy food restriction	4 (25.0)	1 (6.3)	3 (18.8)
Healthy food promotion	3 (18.8)	0 (0)	2 (12.5)
Food price monitor/control	2 (12.5)	0 (0)	2 (12.5)
Having nutrition guidelines	2 (12.5)	0 (0)	2 (12.5)
School physical education classes (yes/no)	16 (100)	9 (56.3)	15 (93.8)
Extracurricular physical activity requirement (yes/no)	14 (87.5)	9 (56.3)	7 (43.8)
School physical examination (yes/no)	16 (100)	10 (62.5)	16 (100)
School cafeteria utilization index[a] (school average times per week)	3.0 ± 1.8	—	—
School cafeteria popularity index[b] (0–1)	0.4 ± 0.2	—	—

[a]School cafeteria utilization index was calculated by averaging the weekly frequency of dining in school cafeterias by each student within schools. [b]School cafeteria popularity index was defined as the proportion of students who liked the school cafeteria.

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Table 3. Associations between having certain school food environment/policy factors and student eating behaviors (as outcomes) in four megacities in China, Childhood Obesity Study in China Megacities, 2015[a]

	Incidence rate ratio (95% confidential interval)			
	Beverage	*Snack*	*Fast food*	*Eat at food stall*
All (N = *1457)*				
School cafeteria food policy	1.05 (0.94, 1.18)	1.08 (0.96, 1.23)	1.08 (0.92, 1.28)	1.17 (0.94, 1.46)
Campus food store policy	**0.54*** (0.47, 0.61)**	**0.84** (0.74, 0.95)**	**0.58** (0.42, 0.81)**	0.97 (0.81, 1.17)
School vicinity food stall policy	**0.70*** (0.61, 0.80)**	**0.78** (0.67, 0.92)**	**0.56** (0.39, 0.80)**	**1.61*** (1.26, 2.07)**
School cafeteria utilization[b]	1.00 (0.96, 1.04)	1.02 (0.99, 1.05)	1.01 (0.96, 1.05)	1.00 (0.95, 1.05)
School cafeteria popularity[c]	0.77 (0.49, 1.21)	1.02 (0.76, 1.37)	1.16 (0.61, 2.23)	1.23 (0.66, 2.29)
Boys (N = *738)*				
School cafeteria food policy	1.03 (0.86, 1.22)	**1.20* (1.03,1.40)**	0.86 (0.69, 1.08)	1.07 (0.87, 1.33)
Campus food store policy	**0.54*** (0.44, 0.66)**	**0.70*** (0.61, 0.81)**	**0.29*** (0.19, 0.43)**	0.98 (0.73, 1.32)
School vicinity food stall policy	**0.63*** (0.48, 0.83)**	**0.80* (0.65, 0.98)**	**0.41*** (0.27, 0.63)**	**1.45* (1.06, 1.98)**
School cafeteria utilization[b]	1.00 (0.94, 1.05)	1.01 (0.98, 1.05)	0.99 (0.95, 1.04)	1.02 (0.96, 1.08)
School cafeteria popularity[c]	0.76 (0.51, 1.13)	1.17 (0.79, 1.75)	0.89 (0.48, 1.64)	0.95 (0.60, 1.51)
Girls (N = *719)*				
School cafeteria food policy	1.10 (0.95, 1.26)	1.01 (0.88, 1.15)	**1.30** (1.08, 1.57)**	1.26 (0.96, 1.66)
Campus food store policy	**0.54*** (0.45, 0.65)**	0.92 (0.78, 1.09)	0.89 (0.63, 1.27)	0.96 (0.75, 1.22)
School vicinity food stall policy	**0.78** (0.66, 0.91)**	**0.79** (0.68, 0.93)**	0.73 (0.52, 1.03)	**1.77*** (1.31, 2.39)**
School cafeteria utilization[b]	1.00 (0.94, 1.06)	1.02 (0.98, 1.06)	1.02 (0.95, 1.08)	0.98 (0.91, 1.04)
School cafeteria popularity[c]	0.79 (0.37, 1.68)	0.91 (0.58, 1.42)	1.76 (0.83, 3.72)	1.65 (0.54, 5.02)

Abbreviation: BMI, body mass index. Numbers in bold indicate statistical significance (*$P < 0.05$, **$P < 0.01$ and ***$P < 0.00$). [a]All negative binomial regression models adjusted for age, sex, father's and mother's BMI, parental highest education, family living condition and pocket money per week. [b]School cafeteria utilization index was calculated by averaging the weekly frequency of dining in school cafeterias by each student within schools. [c]School cafeteria popularity index was defined as the proportion of students who liked the school cafeteria.

less sensitive to school food policies. A possible explanation for this gendered pattern is that girls face more social controls over eating and body weight other than school policies, which may conceivably attenuate influences from school policies. For example, girls bear more sociocultural pressure for thinness as an ideal body image than boys.[30–32] Moreover, temperance in eating is more often linked to feminine virtues such as self-restraint and moderation.[33] In contrast, plumpness for boys is often linked to 'health', 'prosperity' and 'good fortune',[34] while large appetite, as large physical stature, is often regarded as masculine.[35] Conforming to the gendered norms, parents often police girls' appetite to pressure their daughters into a socially desirable body shape.[36] Internalization of the 'thinness-as-beauty mandate' may also prompt girls to practice self-control in food intake and weight management.[37] Given the presence of multiple sources of influences on girls' eating and body weight, the association between school food policies and overweight/obesity risks for girls might be offset to a certain extent.

It is somewhat counterintuitive that policies on SVFS were positively associated with frequency of eating at street food stalls. A possible explanation might be related to the issue of reversed causality, that is, regulations on SVFS were triggered by frequent students' consumption of street foods. Future studies with longitudinal design are warranted to shed more light on this issue.

Interestingly, SC policies were positively associated with snack intake among boys, and fast food consumption among girls. These findings may suggest that food regulations in SC may have some unintended consequences in triggering students' compensatory eating, that is, limits placed on certain types of foods (mostly unhealthy but palatable) in SC may prompt students to seek those foods from other sources. The positive associations of SC policies with different eating behaviors among boys (that is, snacks) and girls (that is, fast food) may suggest the existence of gender-specific compensatory eating behaviors. Future qualitative studies are needed to examine whether and why gender-specific compensatory eating behaviors exist.

Our findings have several public health implications. First, school policies promoting healthy eating are particularly important for obesity prevention among boys in urban China. Second, SC should be a major site for intervention, as our findings suggested that SC food policies and higher utilization of SC were associated with lower risk of overweight/obesity for boys. Third, future school-based interventions need to attend to possible unintended consequences of unhealthy food restriction in SCs,

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Table 4. Associations between school environment/policy factors and student weight status, Childhood Obesity Study in China Megacities, 2015[a]

	Odds ratio (95% confidential Interval)					
	Overweight and obesity[b]			*Central obesity*[c]		
	Overall	*Boys*	*Girls*	*Overall*	*Boys*	*Girls*
Sample size	1457	738	719	1457	738	719
School cafeteria food policy	**0.54***** **(0.39, 0.75)**	**0.60***** **(0.46, 0.79)**	**0.48**** **(0.28, 0.82)**	0.88 (0.73, 1.05)	**0.79***** **(0.70, 0.89)**	1.06 (0.70, 1.59)
Campus food store policy	0.95 (0.70, 1.29)	**0.74**** **(0.62, 0.90)**	1.42 (0.67, 3.00)	0.80 (0.62, 1.05)	**0.67*** **(0.48, 0.92)**	0.91 (0.48, 1.73)
School vicinity food stall policy	**0.56*** **(0.35, 0.89)**	**0.51***** **(0.35, 0.73)**	0.74 (0.27, 2.02)	**0.61**** **(0.45, 0.83)**	**0.63**** **(0.48, 0.84)**	0.57 (0.25, 1.31)
School cafeteria utilization[d]	0.94 (0.85, 1.04)	**0.91*** **(0.84, 0.99)**	0.99 (0.83, 1.19)	1.04 (0.97, 1.12)	0.98 (0.91, 1.06)	1.12 (0.98, 1.28)
School cafeteria popularity[e]	1.29 (0.50, 3.38)	1.27 (0.58, 2.78)	1.16 (0.23, 5.91)	1.48 (0.62, 3.54)	0.97 (0.56, 1.69)	2.41 (0.50, 11.68)
Extracurricular PA requirement	0.92 (0.74, 1.14)	0.98 (0.82, 1.18)	0.80 (0.47, 1.36)	0.98 (0.69, 1.39)	1.22 (0.96, 1.55)	0.75 (0.35, 1.60)

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force. Numbers in bold indicate statistical significance ($^{*}P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$). [a]All logistic regression models adjusted for age, sex, father's and mother's BMI, parental highest education, family living condition and pocket money per week. [b]Overweight and obesity were defined based on the IOTF-recommended age- and sex-specific cutoffs corresponding to BMI $\geqslant$ 25 and 30 kg m^{-2} at age 18 years, respectively. [c]Central obesity was defined based on the age- and sex-specific cutoffs corresponding to the 85th percentile of waist circumference. [d]School cafeteria utilization index was calculated by averaging the weekly frequency of dining in school cafeterias by each student within schools. [e]School cafeteria popularity index was defined as the proportion of students who liked the school cafeteria.

that is, students may 'compensate' their need for palatable but energy-dense food through alternative sources. Thus, besides policy leverages, it is important to educate student in terms of how to eat healthily on their own. Fourth, future policies need to focus on multiple locales (for example, CFS, SVFS, etc.) to build up a healthy school food environment. Finally, school policies need to be designed under close partnership between schools and local governments. Local governments are essential in regulating the immediate neighborhood context of school, which is usually beyond the school jurisdiction. Supports from local governments would give powerful leverage to school administrations in regulating the campus environment.

This study has some limitations. First, the cross-sectional design prevents us from making strong causal inferences. Second, no information was collected regarding student's PA at school (although students were asked to report their PA after school), thus not allowing us to examine whether/how school policies may affect students energy expenditure. Finally, given that policy information was collected based on survey instruments instead of in-depth interviews, more qualitative characteristics about these policies (for example, quality of policy implementation) were not available in the current wave of data.

Despite its limitations, the study draw a nuanced picture of energy-balance-related SEP in urban China, based on rich information on multiple types of school policies and from students, their parents and schools. Notably, information on regulators enables us to see for the first time major players in shaping SEPs in urban China, which is informative for future interventions. Moreover, measured height and weight were collected. Finally, through examining eating behaviors, this study shed light on possible energy-intake pathways linking school policies and students' weight status.

In conclusion, to our knowledge, this is the first study that systematically examined the current state of multiple types of food policies at multiple school locales (on and off campus) in four Chinese megacities that bear heavy burdens of childhood obesity. We found that policies regulating school food environment were heterogeneously implemented even among these four cities, and that school administrations and local governments played different roles in advancing these policies. Students' consumption of sugary beverage, snack and fast food were significantly lower with the presence of regulations on CFS and SVFS. Boys' risk of overweight/obesity and central obesity were significantly lower in schools with policies on SCs, CFS and SVFS, while girls' risk of overweight/obesity was lower in schools regulating SCs. Taken together, these findings suggest that effective government and school policies and programs are needed in China for fighting the growing obesity epidemic, and that future childhood obesity interventions in China need to be based on coordinated efforts from both school administrations and local governments.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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