

Association between convenience stores near school and obesity among school-aged children in Beijing, China

Shuang Zhou

department of maternal and child health, school of public health, peking university

Yu Cheng

department of maternal and child health, school of public health, peking university

Lan Cheng

leibniz institute for prevention research and epidemiology-BIPS

Di Wang

department of maternal and child health, school of public health, peking university

Qin Li

reproductive medicine center, peking university third hospital

Zheng Liu

department of maternal and child health, school of public health, peking university

Haijun Wang (✉ whjun1@bjmu.edu.cn)

Peking University School of Public Health <https://orcid.org/0000-0003-0849-2903>

Research article

Keywords: Obesity, Convenience store, School, Children

Posted Date: January 10th, 2020

DOI: <https://doi.org/10.21203/rs.2.20584/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published on January 31st, 2020. See the published version at <https://doi.org/10.1186/s12889-020-8257-0>.

Abstract

Background: Food environments have rapidly changed over the past years in China and children have more access to unhealthy food in convenience stores near school. Since the studies on the association between convenience stores near school and obesity had inconsistent results and no similar study in China, we conducted the study on the association in Beijing of China, which will provide scientific evidence for intervention of childhood obesity.

Methods: The study included 2201 students at grade 4 of 37 primary schools in Dongcheng or Miyun district of Beijing. The food environment data was acquired from AMAP, the free web-based geospatial service provider. The numbers of convenience stores were captured within the 800 meter network buffer near school using Geographic Information System. The weight and height of each student were measured by trained health professionals. Students' dietary and physical behaviors and other information associated with obesity were collected with questionnaires for students and their parents. Generalized linear mixed model was used to analyze the data.

Results : The average age of the students was 10.2 years (SD=0.33). The prevalence of obesity in students was 14.9%. The median number of convenience stores within the 800 meter network buffer near school was 24 in two districts. The number of convenience stores near each school varied from 5 to 67 (median: 25) in Dongcheng district and from 1 to 57 (median: 22) in Miyun district. After adjusting for the confounding factors at the family and individual levels, the association between convenience stores and childhood obesity was statistically significant. Additional ten convenience stores near school were associated with an increased risk of obesity (OR=1.13, 95%CI : 1.03,1.24, P =0.011). Compared with less than 24 convenience stores near school, the students with more than or equal to 24 convenience stores near school had an increased risk of obesity (OR=1.49, 95% CI : 1.09, 2.03, P =0.013).

Conclusion: The students with more convenience stores near their schools had an increased risk of obesity. The findings provided evidences for developing public health policy to restrict the number of convenience stores near school to prevent and control childhood obesity.

Background

Childhood obesity has emerged to be a major public health problem. Based on the Chinese National Survey on Students Constitution and Health, the prevalence of overweight and obesity in Chinese children and adolescents has increased continuously since 1985, reaching 19.4% in 2014[1]. Children with obesity have an increased risk of asthma[2], diabetes[3], evaluated blood pressure[4] and other cardiometabolic risk factors[5]. The risk persists to adults, with increased risk of metabolic syndrome[6], cancer[7], non-alcoholic fatty liver[8], and cardiovascular mortality[9, 10].

Childhood obesity is a complex condition associated with the interaction of genetics and environmental factors which include physical activity, diet, and other relevant factors[11]. Recently policy makers and researchers have paid special attention to obesogenic environments [12]. A lot of previous studies have

focused on the obesogenic effect of convenience stores[13]. The convenience stores near school may be one of obesogenic environments for students, because many unhealthy food are sold in convenience stores, such as sugar sweetened beverages and energy-dense snacks[14] and very limited healthy food[15]. Especially, a previous study found that students aged 10 to 14 years old bought snacks mostly in the convenience stores rather than other type of food stores[16]. Many school-aged children would like to buy unhealthy food such as sugar sweetened beverages and energy-dense snacks on the way to school and from school[17], which may increase the intake of energy. That the energy intake is more than the energy expenditure will result in childhood obesity.

Because of the potential role of convenience stores near school on students' diet behaviors of the intake of fruits, vegetables, snacks and fizzy drinks[18], some studies investigated the association of convenience stores near school and childhood obesity. However, there is no consensus on the role of convenience stores on childhood obesity. A few studies have demonstrated that convenience stores near school increased the risk of children's overweight or obesity[19–22], while others have showed an inverse association[23] or statistically insignificant association[24–32]. What's more, the studies focusing on the association of convenience stores near school and children's nutritional status were carried out in the USA[19, 21–23, 26, 28, 30], England[24, 27, 31], Canada[25, 26], and South Korea[29]. Only two studies investigated the association of convenience stores near school and children's fatness in Chinese Taiwan[32, 33]. However, both of the studies were hampered by the limitation that they investigated the convenience stores in a circular buffer of schools without consideration of street network[32, 33]. To our knowledge, there is no evidence on the association of convenience stores near school and obesity of school-aged children in mainland of China. Since food environments and diet culture vary among different countries or regions[34, 35], it would be important to study its role on childhood obesity in mainland of China.

The mainland of China has been facing the rapid economic growth and dramatic change of food environments, so children have more access to unhealthy food in convenience stores near school. We conducted the study aiming to elucidate the association of convenience stores near school and obesity of school-aged children in Beijing of China, providing scientific evidence for the intervention of childhood obesity.

Methods

Study population

We recruited participants at grade 4 of 37 primary schools in Dongcheng or Miyun district of Beijing, China, from May to June in 2016. Inclusion criteria for schools were as follows: Firstly, non-boarding, non-specialty and non-minority schools. Secondly, schools with no less than 50 students at grade 4. Thirdly, schools' leaders agreed to participate in the study. All the eligible primary schools (43 schools) which met the inclusion criteria were invited to complete the school-based obesity prevention survey. Finally, 37 of the 43 schools (86%) provided approval for the study, including 23 schools in Dongcheng district and 14

schools in Miyun district (Figure S1). We used the method of cluster sampling to recruit students in each school. All students in the 2-3 selected classes received the informed consent forms. We included the students whose parents agreed and signed the informed consent forms in the study. Exclusion criteria were as follows: firstly, children with diseases of heart, lung, liver, kidney and other important organs (such as heart disease, hypertension, tuberculosis, asthma, hepatitis, and nephritis). Secondly, children with obesity caused by other reasons such as endocrine diseases, side effects of drugs and so on. Thirdly, children with dysplasia such as dwarfism and gigantism. Fourthly, children with body disability and malformation such as severe scoliosis, pigeon breast, lameness, Knock Knees, Bowlegs and so on. Finally, 2201 students of 37 primary schools were included in our study.

Anthropometric measurement and Definition of obesity

Height (cm) and weight (kg) were measured according to the standard procedure. Participants were required to wear light clothes and stand straight, barefoot and at ease when being measured. Weight was measured to the nearest 0.1 kg with a standardized lever scale and height to the nearest 0.1 cm with a portable stadiometer. Both the scales and stadiometers were calibrated before measurement. Body mass index (BMI) was calculated as body weight (kg) divided by height (m) squared (kg/m^2). We used the standard of Working Group on Obesity in China (WGO) to define the nutritional status[36]. Obesity was defined as BMI more than or equal to 95th percentile at the age-and sex-specific group[36].

Questionnaire investigation

We investigated students' age, gender, physical activities, diet behaviors and other individual and family factors related to obesity with questionnaires for students and their parents. We collected students' intake of vegetables, fruits, meat, milk and sugar sweetened beverages in the past seven days with the students' questionnaires. We designed the questions of the students' diet behaviors according to the Block Kids Food Screener (BKFS). The validity study showed that the correlation between BKFS and three 24-h dietary recalls was 0.526, 0.600, 0.681, 0.478, 0.869 in the intake of vegetables, fruits, meat, sugar sweetened beverages, and milk, respectively[37]. We asked the students about the frequency and amount of the foods and beverages consumed in the past seven days. For example, the following questions "How many days do you eat vegetables in the past seven days" and "How much do you eat on the days you eat vegetables" were asked. The frequency was zero to seven days and the amount was half of one portion, one portion, two portions, and more than or equal to three portions. One portion was 150 grams for vegetables and fruits, 80-100 grams for meat, and 250 milliliters for sugar sweetened beverages and milk. According to the Dietary Approaches to Stop Hypertension (DASH)[38], in the Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, we adopted the following evaluation criteria. The recommended intakes of vegetables and fruits were more than 3 portions and 2 portions per day, respectively. The recommendation of meat intake was less than 2 portions per day for

boys and 1 portion per day for girls. The recommendation of milk was more than 2 portions per day. The recommended intake of sugar sweetened beverages was less than 3 portions per week. If the intake of vegetables, fruits, and milk reached or exceeded the recommendation, the score was 1, else, the score was the actual intake divided by the recommended amount. If the intakes of meat and sugar sweetened beverages were within the recommendation, the score was 1, else, the score was $1 - (\text{actual intake} - \text{recommended amount}) / \text{recommended amount}$, and if the score was negative, we recorded the score as zero. We calculated the score of dietary pattern as the sum of all the above scores. The summed score ranged zero to five and the high score reflected greater adherence to the recommended dietary intakes. We investigated the physical behaviors according to the American Youth Risk Behavior Survey Questionnaire[39], and the recommendation of physical activity was that children had moderate or vigorous physical activities for more than or equal to one hour every day[40]. According to the guideline of screen time for children and adolescents in American Academy of Pediatrics, the recommendation of screen time was less than two hours every day[41]. We collected the information of parents' height, weight, and education with the questionnaire for parents.

Density of convenience stores

We used AMAP, the free web-based geospatial service provider, to geocode and locate the schools' addresses. By using the Application Programming Interface (API) on the AMAP open platform, we accessed to Point of Interest data (POI). Convenience stores were defined as the POI from 060200 to 060202 in AMAP, which included all small convenience stores and grocery stores such as 7-ELEVEN, good neighbor, Lin Jia, and other chain and non-chain convenience stores. We calculated the density of convenience stores located within a 800 meter street network buffer of school centroid. We used the 800 meter buffer for the reason that it approximately corresponded to 10- minute walk, which was commonly used in previous studies[13].

We also undertook an on-foot ground audit in 8 schools. We recorded the actual information of the convenience stores and compared the differences of the information between the AMAP and the ground audit. We also calculated the accuracy of the convenience stores from the map, by the number from both map and ground audit divided by the number from ground audit. Finally, the accuracy for the convenience stores was 80.9%, which was similar to the previous study[42].

Statistical analyses

Means and standard deviations were calculated for continuous variables with normal distribution, while medians and interquartile ranges for variables without normal distribution. Frequencies were calculated for categorical variables. We defined more than or equal to the median number of convenience stores as more convenience stores and less than the median number as less convenience stores. We tested

differences between Dongcheng district and Miyun district in categorical characteristics with chi-square test, normally distributed continuous characteristics with t test, non-normally distributed continuous characteristics with Wilcoxon signed-rank test.

We used Generalized Linear Mixed Model to explore the association of childhood obesity and convenience stores near schools. We used childhood obesity (obesity=1, non-obesity=0) as outcome variable and the number of convenience stores as the continuous predictor or more convenience stores as the categorical predictor. PROC GLIMMIX procedure was run with schools modelled as a random effect because of the cluster sampling of schools, using logit as the link function. Based on the previous studies on the association between food environment and childhood obesity [13], we chose the district level, family level and individual level covariates and adjusted the covariates in the order of district, family, and individual level. First, we used the null model (model 1), not controlling for covariates, to examine the association of childhood obesity and convenience stores. Secondly, we used model 2 to adjust for district. Next model 3 further included the family confounding factors, i.e. whether the parents were obese, parents' education levels, and family type (with only one child, or with more than one child). And then model 4 further adjusted for age and gender of children. Finally, in the full model 5, we further adjusted for dietary and physical behaviors of children that involved the score of dietary pattern, meeting the recommendation of moderate or vigorous physical activities, and meeting the recommendation of screen time. The model was built as follows:

[See supplemental files for the formula.]

All statistical analyses were performed by using SAS 9.4.

Results

General characteristics

The 2201 students at grade 4 of 37 schools participated in the study. The characteristics of students were shown in Table 1. The average age was 10.2 years (SD = 0.33). 50.3% of the students were boys. The prevalence of obesity in students was 14.9%. Students in Dongcheng district were younger than those in Miyun District. More students in Miyun district had siblings, had obese parents and had parents with low education than those in Dongcheng district.

Table 1
General characteristics of participants and convenience stores in the study

Variables	All	Dongcheng District	Miyun District	p ^a
Age, year (mean ± SD)	10.2 ± 0.33	10.2 ± 0.33	10.3 ± 0.33	0.017 ^b
Gender (%)				0.423 ^c
Boy	1107 (50.3)	633 (49.6)	474 (51.3)	
Girl	1094 (49.7)	644 (50.4)	450 (48.7)	
Obesity (%)				0.618 ^c
Yes	329 (14.9)	195 (15.3)	134 (14.5)	
No	1872 (85.1)	1082 (84.7)	790 (85.5)	
Family type (%)				< 0.001 ^c
with only one child	1595 (73.2)	1014 (80.2)	581 (63.6)	
with more than one child	584 (26.8)	251 (19.8)	333 (36.4)	
Father's Obesity (%)				< 0.001 ^c
Yes	381 (17.7)	192 (15.3)	189 (21.1)	
No	1767 (82.3)	1060 (84.7)	707 (78.9)	
Mother's Obesity (%)				< 0.001 ^c

a: P value for differences in general characteristics between Dongcheng district and Miyun district

b: Difference was tested using t test

c: Difference was tested using chi-square test

d: Difference was tested using Wilcoxon signed-rank test

Variables	All	Dongcheng District	Miyun District	p ^a
Yes	149 (6.9)	59 (4.7)	90 (10.0)	
No	2002 (93.1)	1190 (95.3)	812 (90.0)	
Father's Education (%)				< 0.001 ^c
Primary school or below	59 (2.7)	13 (1.0)	46 (5.1)	
Junior high school	338 (15.7)	72 (5.8)	266 (29.7)	
High school or Technical secondary school	461 (21.5)	159 (12.7)	302 (33.7)	
Junior college or Vocational college	400 (18.6)	253 (20.2)	147 (16.4)	
University degree or above	891 (41.5)	755 (60.3)	136 (15.2)	
Mother's Education (%)				< 0.001 ^c
Primary school or below	74 (3.4)	23 (1.8)	51 (5.7)	
Junior high school	376 (17.5)	81 (6.5)	295 (32.8)	
High school or Technical secondary school	435 (20.2)	166 (13.3)	269 (29.9)	
Junior college or Vocational college	423 (19.7)	279 (22.3)	144 (16.0)	
University degree or above	843 (39.2)	702 (56.1)	141 (15.7)	
Number of convenience stores within 800 m network buffer near school				0.597 ^d
Median	24	25	22	

a: P value for differences in general characteristics between Dongcheng district and Miyun district

b: Difference was tested using t test

c: Difference was tested using chi-square test

d: Difference was tested using Wilcoxon signed-rank test

Variables	All	Dongcheng District	Miyun District	p ^a
Interquartile range	(14, 43)	(15, 38)	(3, 45)	
Range	(1, 67)	(5, 67)	(1, 57)	
a: P value for differences in general characteristics between Dongcheng district and Miyun district				
b: Difference was tested using t test				
c: Difference was tested using chi-square test				
d: Difference was tested using Wilcoxon signed-rank test				

Dietary and physical behaviors

Table 2 showed the dietary and physical behaviors of the students. The average score of diet pattern was 3.5 (SD = 0.78). Only the average consumptions of meat and sugar sweetened beverages met the recommendation, while the intakes of vegetables, fruits, and milk were all less than the recommendation. Only 15.5% students met the recommendation of moderate or vigorous physical activities. And 81.1% students met the recommendation of screen time of less than 2 hours everyday. Students in Dongcheng district had a higher sum of diet score than those in Miyun district. Students in Dongcheng district ate more vegetables, fruits, meat, and milk, however, less sugar sweetened beverages than those in Miyun district.

Table 2

The dietary and physical behaviors among students in the study, mean \pm SD or N (%)

Variables	All	Dongcheng District	Miyun District	P value ^a
Diet score (mean \pm SD)	3.5 \pm 0.78	3.6 \pm 0.75	3.3 \pm 0.80	< 0.001 ^b
Vegetable Intake, portion/day (mean \pm SD)	1.5 \pm 0.90	1.6 \pm 0.91	1.4 \pm 0.87	< 0.001 ^b
Fruit Intake, portion /day (mean \pm SD)	1.5 \pm 0.96	1.6 \pm 0.96	1.3 \pm 0.93	< 0.001 ^b
Meat Intake, portion /day (mean \pm SD)	0.7 \pm 0.69	0.8 \pm 0.74	0.5 \pm 0.59	< 0.001 ^b
SSB Intake, portion /week (mean \pm SD)	1.9 \pm 3.16	1.5 \pm 2.67	2.4 \pm 3.66	< 0.001 ^b
Milk Intake, portion /day (mean \pm SD)	1.1 \pm 0.89	1.2 \pm 0.91	1.0 \pm 0.86	< 0.001 ^b
Meeting the Recommendation of MVPA (%)				0.208 ^c
Yes	339 (15.5)	186 (14.7)	153 (16.7)	
No	1845 (84.5)	1080 (85.3)	765 (83.3)	
Meeting the Recommendation of Screen time (%)				< 0.001 ^c
Yes	1761 (81.1)	1095 (86.7)	666 (73.3)	

a: P value for differences in general characteristics between Dongcheng district and Miyun district

b: Difference was tested using t test

c: Difference was tested using chi-square test

SSB, sugar sweetened beverages

MVPA, moderate or vigorous physical activities

The recommendation of MVPA was equal to or more than one hour every day

The recommendation of screen time was less than 2 hours every day

Variables	All	Dongcheng District	Miyun District	P value ^a
No	411 (18.9)	168 (13.3)	243 (26.7)	
a: P value for differences in general characteristics between Dongcheng district and Miyun district				
b: Difference was tested using t test				
c: Difference was tested using chi-square test				
SSB, sugar sweetened beverages				
MVPA, moderate or vigorous physical activities				
The recommendation of MVPA was equal to or more than one hour every day				
The recommendation of screen time was less than 2 hours every day				

Convenience stores near school

The number of convenience stores near school were showed in Table 1. There was no statistically significant difference in the numbers of convenience stores within the 800 m network buffer near school between the two districts. The median number of convenience stores within the 800 meter network buffer near school was 24 in two districts. The median numbers of convenience stores within the 800 meter network buffer near school in Dongcheng district and Miyun district were 25 and 22, respectively. There was marked variation in the number of convenience stores within the 800 meter network buffer near each school, ranging from 5 to 67 in Dongcheng district and ranging from 1 to 57 in Miyun district.

Association between the number of convenience stores near school and childhood obesity

In the analysis of generalized linear mixed model (Table 3), we adjusted for the confounding factors at district, family, and individual levels gradually. When we adjusted for the family confounding factors in Model 3, the association between convenience stores and childhood obesity became significant. And when we further adjusted for the individual confounding factors, the risk of childhood obesity increased gradually. In the full model, there was a significant association between convenience stores near school and childhood obesity. We found that additional ten convenience stores near school were associated with an increased risk of obesity (OR = 1.13, 95%CI: 1.03,1.24). After dividing the number of convenience stores according to the median, the association was more significant. Compared with less convenience stores near school (less than 24), students with more convenience stores near school (more than or equal to 24) had an increased risk of obesity (OR = 1.49, 95%CI: 1.09, 2.03).

Table 3

Association between convenience stores within the 800 m network buffer near school and students' obesity in two districts

	Continuous variable (ten additional convenience stores)			Categorical variable* (more convenience store vs less convenience store)		
	OR**	95%CI	P value	OR***	95%CI	P value
Model 1	1.06	(0.97, 1.15)	0.178	1.17	(0.89, 1.54)	0.259
Model 2	1.06	(0.97, 1.15)	0.194	1.16	(0.88, 1.54)	0.291
Model 3	1.09	(1.01, 1.18)	0.030	1.34	(1.02, 1.76)	0.035
Model 4	1.10	(1.01, 1.19)	0.029	1.37	(1.04, 1.81)	0.026
Model 5	1.13	(1.03, 1.24)	0.011	1.49	(1.09, 2.03)	0.013
* Categorical variable was according to 24 : the median number of convenience stores						
** OR for continuous variable was the odds ratio of ten additional convenience stores						
***OR for categorical variable was more than or equal to the median number of 24 versus less than 24 (reference)						
Model 1: null model						
Model 2: adjusted for districts						
Model 3: Model 2 + father's obesity, mother's obesity, family type, father's education, and mother's education						
Model 4: Model 3 + age, gender						
Model 5: Model 4 + diet score, meeting the recommendation of MVPA, and meeting the recommendation of screen time						

Discussion

We found a significant association between convenience stores near school and childhood obesity in our study. Additional ten convenience stores near school were associated with an increased risk of obesity (OR = 1.13, 95%CI: 1.03,1.24). Compared with less than 24 convenience stores near school, the students with more than or equal to 24 convenience stores near school had an increased risk of obesity (OR = 1.49, 95%CI: 1.09, 2.03).

Our findings of a positive association between convenience stores near school and the prevalence of obesity corresponded to some studies carried out in North America. Sanchez et.al[19] found that students with each additional convenience store near school had an estimated 1% higher prevalence of overweight. Howard et.al [21] and Langellier et al[22] showed that the presence of a convenience store within 800 meter buffer was associated with 1.2% and 1.6% higher prevalence of overweight compared with those schools without a convenience store nearby, respectively.

Several studies in western countries were not in accordance with our study, which couldn't identify a significant association between convenience stores near school and childhood obesity. The inconsistency may be due to differences in type of buffer zone, buffer distance, source of information about food environments, definition of food environments, measurement of participants' weight and height, adjustment of the potential covariates of dietary and physical behaviors, and sample size. Some of the studies investigated the food environments in a circular buffer instead of a street network buffer[25–27, 29]. However, researches showed it was better to detect the food environments near schools within a road network buffer than in a circular buffer[43]. The difference of buffer distance may also result in the inconsistency. A 800 meter buffer approximately corresponded to a 10-minute walk[13], while 500 meter or 1000 meter buffer meant a walk for shorter time or longer time, respectively. Type of food bought by students in convenience stores within different distances may be different. The source of information about food environments and their definitions had an impact on the association between the number of convenience stores near school and childhood obesity. Precise information from reliable source was important for the study. Similarly, the accuracy of the weight and height of children was also important, while some studies obtained the information of weight and height by self-report[25, 26, 28]. Physical activities and diet were strongly associated with obesity, which should be controlled in the statistical models. As shown in our results, the risk of childhood obesity increased when we adjusted for the individual dietary and physical behaviors. But some studies were lack of the individual information of dietary or physical behaviors[30, 31]. As we all known that countries with different diet culture sold varied kinds of foods, in other word, children in Beijing of China might have access to different foods compared with foreign children. So it is difficult to compare the results from studies in other countries or regions with that of our study.

In China, there was no study on the association between convenience stores near school and childhood obesity in mainland, and only two studies were conducted in Chinese Taiwan[32, 33]. The two studies didn't find a significant association between convenience stores near school and childhood obesity. The reason why they were inconsistent with our study may be that they investigated the convenience store in a circular buffer of schools without consideration of street network and the distance was 500 meters and 1000 meters, which were different from our study[32, 33].

Studies have also shown that school-aged children would like to buy sugar sweetened beverages and energy-dense snacks when they went to school or went back home[17]. Intake of the unhealthy food will increase the risk of childhood obesity for that the energy intake is in excess of the energy expenditure

[44]. It could explain the number of convenience stores near school is associated with an increased risk of childhood obesity.

Our study had the significance not only for parents, but also for the policy makers. Although China has announced the policy that schools are banned to have retail shops and vending machines within the campus, the significant role of the convenience stores near the campus on childhood obesity was ignored. The findings provided evidences for developing the public health policy to restrict the number of convenience stores near school to prevent and control childhood obesity.

There are some strengths in our study. First, to our knowledge, it was the first study using the geographical information system to investigate the association between convenience stores near school and childhood obesity in mainland of China. Besides, we included informations at district, family, and individual levels, which allowed us to adjust for the potential covariates at different levels. Especially, we adjusted for the dietary and physical behaviors, which were the important influencing factors of obesity, to assess the true association between convenience stores near schools and childhood obesity.

There are some limitations in the present study. First, given the cross-sectional design of our study, it has the limited capability to infer causality between convenience stores near school and childhood obesity. Secondly, although we adjusted for several confounding factors at the district, family, and individual levels, we can't rule out the possibility of residual confounding factors. We didn't adjust other food environment like the density of fast food outlets, supermarkets or other markets in the region and vending machines in the school. However, according to the situation in China, fast food shop serves more expensive foods than convenience stores, and students unlikely go to supermarkets or other markets alone. The Education Committee in Beijing has banned the retail shops and vending machines in the campus since 2013, so there're no retail shops within our study schools. So our study results indicated convenience stores near school had a more important role on primary students in China with little potential for the residual confounding of other type of food stores, which need further studies for validation. What's more, our study was conducted in the two districts of Beijing. Further studies are needed to investigate the association between convenience stores near school and childhood obesity in a large number of Chinese schools in different regions of China.

Conclusion

The students with more convenience stores near their schools had an increased risk of obesity. The findings provided evidences for developing the public health policy to restrict the number of convenience stores near school to prevent and control childhood obesity.

List Of Abbreviations

API
Application Programming Interface

BKFS
Block Kids Food Screener
BMI
Body mass index
CI
Confidence Interval
DASH
Dietary Approaches to Stop Hypertension
GLMM
Generalized linear mixed model
OR
Odds Ratio
POI
Point of Interest data
SD
Standard Deviation
WGOC
Working Group on Obesity in China

Declarations

Ethics approval and consent to participate

The study was approved by the Ethic Committee of Peking University Health Science Centre. The primary caregivers of eligible children provided the written consent to participate in the study.

Consent for publication

The primary caregivers of eligible children provided the written consent for publication.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by National Key R&D Program of China (2016YFC1300204).

Authors' contributions

H.J.W., L.C., Y.C., Q.L., and Z.L. designed the study. L.C., Y.C., and D.W. collected data. S.Z. and Y.C. analyzed and interpreted the data. S.Z. was a major contributor in writing the article. H.J.W. revised and improved drafts of the article. All authors read and approved the final article.

Acknowledgements

We thank all the members in our research team, including investigators, cooperators, fieldworkers, computing, and data management researchers.

References

1. Wang S, Dong YH, Wang ZH, Zou ZY, Ma J: **Trends in overweight and obesity among Chinese children of 7-18 years old during 1985-2014**. *Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine]* 2017, **51**(4):300-305.
2. Vlashki E, Cvejaska Colakovska V, Kimovska M, Ristevska T, Micevska V, Lawson J: **Body mass index and risk of asthma and asthma-like symptoms in childhood**. *Allergy: european journal of allergy and clinical immunology Conference: 36th annual congress of the european academy of allergy and clinical immunology, EAACI 2017 Finland 2017*, **72**:647.
3. Praveen PA, Tandon N: **Childhood obesity and type 2 diabetes in India**. *WHO South-East Asia journal of public health* 2016, **5**(1):17-21.
4. Zhao Y, Wang L, Xue B, Wang Y: **Associations between general and central obesity and hypertension among children: The Childhood Obesity Study in China Mega-Cities**. *Scientific reports* 2017, **7**(1):16895.
5. Friedemann C, Heneghan C, Mahtani K, Thompson M, Perera R, Ward AM: **Cardiovascular disease risk in healthy children and its association with body mass index: systematic review and meta-analysis**. *Bmj* 2012, **345**:e4759.
6. Liang Y, Hou D, Zhao X, Wang L, Hu Y, Liu J, Cheng H, Yang P, Shan X, Yan Y *et al*: **Childhood obesity affects adult metabolic syndrome and diabetes**. *Endocrine* 2015, **50**(1):87-92.
7. Keinan-Boker L, Levine H, Leiba A, Derazne E, Kark JD: **Adolescent obesity and adult male breast cancer in a cohort of 1,382,093 men**. *Int J Cancer* 2018, **142**(5):910-918.
8. Yan Y, Hou D, Zhao X, Liu J, Cheng H, Wang Y, Mi J: **Childhood Adiposity and Nonalcoholic Fatty Liver Disease in Adulthood**. *Pediatrics* 2017, **139**(4).
9. Ohlsson C, Bygdell M, Sonden A, Rosengren A, Kindblom JM: **Association between excessive BMI increase during puberty and risk of cardiovascular mortality in adult men: a population-based cohort study**. *Lancet Diabetes Endocrinol* 2016, **4**(12):1017-1024.
10. Twig G, Yaniv G, Levine H, Leiba A, Goldberger N, Derazne E, Ben-Ami Shor D, Tzur D, Afek A, Shamiss A *et al*: **Body-Mass Index in 2.3 Million Adolescents and Cardiovascular Death in Adulthood**. *The New England journal of medicine* 2016, **374**(25):2430-2440.

11. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS: **Childhood obesity: causes and consequences.** *Journal of family medicine and primary care* 2015, **4**(2):187-192.
12. Townshend T, Lake A: **Obesogenic environments: current evidence of the built and food environments.** *Perspectives in public health* 2017, **137**(1):38-44.
13. Williams J, Scarborough P, Matthews A, Cowburn G, Foster C, Roberts N, Rayner M: **A systematic review of the influence of the retail food environment around schools on obesity-related outcomes.** *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2014, **15**(5):359-374.
14. Lucan SC, Karpyn A, Sherman S: **Storing empty calories and chronic disease risk: snack-food products, nutritive content, and manufacturers in Philadelphia corner stores.** *Journal of urban health : bulletin of the New York Academy of Medicine* 2010, **87**(3):394-409.
15. Gebauer H, Laska MN: **Convenience stores surrounding urban schools: an assessment of healthy food availability, advertising, and product placement.** *Journal of urban health : bulletin of the New York Academy of Medicine* 2011, **88**(4):616-622.
16. Engler-Stringer R, Schaefer J, Ridalls T: **An examination of the roles played by early adolescent children in interactions with their local food environment.** *Can J Public Health* 2016, **107**(Suppl 1):5296.
17. Borradaile KE, Sherman S, Vander Veur SS, McCoy T, Sandoval B, Nachmani J, Karpyn A, Foster GD: **Snacking in children: the role of urban corner stores.** *Pediatrics* 2009, **124**(5):1293-1298.
18. Smith D, Cummins S, Clark C, Stansfeld S: **Does the local food environment around schools affect diet? Longitudinal associations in adolescents attending secondary schools in East London.** *BMC Public Health* 2013, **13**:70.
19. Sanchez BN, Sanchez-Vaznaugh EV, Uscilka A, Baek J, Zhang L: **Differential associations between the food environment near schools and childhood overweight across race/ethnicity, gender, and grade.** *Am J Epidemiol* 2012, **175**(12):1284-1293.
20. Virtanen M, Kivimaki H, Ervasti J, Oksanen T, Pentti J, Kouvonen A, Halonen JI, Kivimaki M, Vahtera J: **Fast-food outlets and grocery stores near school and adolescents' eating habits and overweight in Finland.** *Eur J Public Health* 2015, **25**(4):650-655.
21. Howard PH, Fitzpatrick M, Fulfrost B: **Proximity of food retailers to schools and rates of overweight ninth grade students: an ecological study in California.** *BMC Public Health* 2011, **11**:68.
22. Langellier BA: **The food environment and student weight status, Los Angeles County, 2008-2009.** *Prev Chronic Dis* 2012, **9**:E61.
23. Tang X, Ohri-Vachaspati P, Abbott JK, Aggarwal R, Tulloch DL, Lloyd K, Yedidia MJ: **Associations between food environment around schools and professionally measured weight status for middle and high school students.** *Child Obes* 2014, **10**(6):511-517.
24. Green MA, Radley D, Lomax N, Morris MA, Griffiths C: **Is adolescent body mass index and waist circumference associated with the food environments surrounding schools and homes? A longitudinal analysis.** *BMC Public Health* 2018, **18**(1):482.

25. Seliske LM, Pickett W, Boyce WF, Janssen I: **Association between the food retail environment surrounding schools and overweight in Canadian youth.** *Public Health Nutr* 2009, **12**(9):1384-1391.
26. Heroux M, Iannotti RJ, Currie D, Pickett W, Janssen I: **The food retail environment in school neighborhoods and its relation to lunchtime eating behaviors in youth from three countries.** *Health & place* 2012, **18**(6):1240-1247.
27. Griffiths C, Frearson A, Taylor A, Radley D, Cooke C: **A cross sectional study investigating the association between exposure to food outlets and childhood obesity in Leeds, UK.** *The international journal of behavioral nutrition and physical activity* 2014, **11**:138.
28. Harris DE, Blum JW, Bampton M, O'Brien LM, Beaudoin CM, Polacsek M, O'Rourke KA: **Location of food stores near schools does not predict the weight status of Maine high school students.** *J Nutr Educ Behav* 2011, **43**(4):274-278.
29. Park S, Choi BY, Wang Y, Colantuoni E, Gittelsohn J: **School and neighborhood nutrition environment and their association with students' nutrition behaviors and weight status in Seoul, South Korea.** *The Journal of adolescent health : official publication of the Society for Adolescent Medicine* 2013, **53**(5):655-662.e612.
30. Laska MN, Hearst MO, Forsyth A, Pasch KE, Lytle L: **Neighbourhood food environments: are they associated with adolescent dietary intake, food purchases and weight status?** *Public Health Nutr* 2010, **13**(11):1757-1763.
31. Williams J, Scarborough P, Townsend N, Matthews A, Burgoine T, Mumtaz L, Rayner M: **Associations between Food Outlets around Schools and BMI among Primary Students in England: A Cross-Classified Multi-Level Analysis.** *PLoS One* 2015, **10**(7):e0132930.
32. Chiang PH, Wahlqvist ML, Lee MS, Huang LY, Chen HH, Huang ST: **Fast-food outlets and walkability in school neighbourhoods predict fatness in boys and height in girls: a Taiwanese population study.** *Public Health Nutr* 2011, **14**(9):1601-1609.
33. Chiang PH, Huang LY, Lee MS, Tsou HC, Wahlqvist ML: **Fitness and food environments around junior high schools in Taiwan and their association with body composition: Gender differences for recreational, reading, food and beverage exposures.** *PLoS One* 2017, **12**(8):e0182517.
34. Walker C, Gibney ER, Hellweg S: **Comparison of Environmental Impact and Nutritional Quality among a European Sample Population - findings from the Food4Me study.** *Scientific reports* 2018, **8**(1):2330.
35. Cummins S, Macintyre S: **Food environments and obesity—neighbourhood or nation?** *Int J Epidemiol* 2006, **35**(1):100-104.
36. **[Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents].** *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi* 2004, **25**(2):97-102.
37. Hunsberger M, O'Malley J, Block T, Norris JC: **Relative validation of Block Kids Food Screener for dietary assessment in children and adolescents.** *Matern Child Nutr* 2015, **11**(2):260-270.

38. **Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report.** *Pediatrics* 2011, **128 Suppl 5**:S213-256.
39. Brener ND, Kann L, McManus T, Kinchen SA, Sundberg EC, Ross JG: **Reliability of the 1999 youth risk behavior survey questionnaire.** *The Journal of adolescent health : official publication of the Society for Adolescent Medicine* 2002, **31**(4):336-342.
40. **WHO Guidelines Approved by the Guidelines Review Committee.** In: *Global Recommendations on Physical Activity for Health.* edn. Geneva: World Health Organization Copyright (c) World Health Organization 2010.; 2010.
41. **American Academy of Pediatrics: Children, adolescents, and television.** *Pediatrics* 2001, **107**(2):423-426.
42. Wong MS, Peyton JM, Shields TM, Curriero FC, Gudzone KA: **Comparing the accuracy of food outlet datasets in an urban environment.** *Geospatial health* 2017, **12**(1):546.
43. Seliske L, Pickett W, Rosu A, Janssen I: **The number and type of food retailers surrounding schools and their association with lunchtime eating behaviours in students.** *The international journal of behavioral nutrition and physical activity* 2013, **10**:19.
44. Kumar S, Kelly AS: **Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment.** *Mayo Clinic proceedings* 2017, **92**(2):251-265.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Formula.docx](#)
- [supplimentaryfile.docx](#)