



The associations of specific school- and individual-level characteristics with obesity among primary school children in Beijing, China

Lan Cheng^{1,2}, Qin Li¹, Antje Hebestreit², Yi Song³, Di Wang¹, Yu Cheng¹ and Hai-Jun Wang^{1,*}

¹Department of Maternal and Child Health, School of Public Health, Peking University, Beijing, China: ²Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany: ³Institute of Child and Adolescent Health, Peking University, Beijing, China

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Abstract

Objective: We aimed to investigate the associations between school-level characteristics and obesity among Chinese primary school children with consideration of individual-level characteristics.

Design: This cross-sectional study was conducted in 2015/2016. School-level characteristics were assessed using an interviewer-administered school questionnaire, and a 'school-based obesity prevention index' was further developed. Individual-level characteristics were collected by self-administered questionnaires. Objectively measured height and weight of students were collected, and obesity status was classified according to the International Obesity Task Force criteria for Asian children. Generalised linear mixed models were used to estimate the associations among the school- and individual-level characteristics and obesity of students.

Setting: Thirty-seven primary schools from an urban and a rural district of Beijing, China.

Participants: School staffs, 2201 students and their parents.

Results: The school-based obesity prevention index involved the number of health professionals, availability of students' health records, monitoring students' nutrition status, frequency of health education activities, reporting achievements of obesity prevention activities to parents, duration of physical activity during school time and availability of playground equipment. The prevalence of obesity was lower in schools with the higher index value compared with that in schools with the lower index value (OR 0.56; 95% CI 0.40, 0.79). Some individual-level characteristics were negatively associated with childhood obesity: liking sports, duration of screen time ≤ 2 h/d, perceived lower eating speed, parental non-overweight/obesity.

Conclusions: Irrespective of individual-level characteristics, the specific school-level characteristics had a cumulative effect on obesity among Chinese primary school children. Further school-based obesity intervention should consider these characteristics simultaneously.

Keywords
Paediatric obesity
School
Cross-sectional study
Public health

The rising prevalence of childhood obesity has been a global pandemic, not only in developed countries but also in developing countries^(1,2). Obesity during childhood is not only associated with an increased risk for impaired glucose tolerance and hypertension but also can increase the risk of chronic diseases including diabetes and some cancers during adulthood^(3,4). Data

from the 2014 Chinese National Survey on Students Constitution and Health indicated that among Chinese students aged 7–18, 9.4% of boys and 5.1% of girls were obese and the prevalence has increased dramatically from 1985 to 2014⁽⁵⁾. Given the substantial rise in the prevalence of obesity among children, modifiable behavioural factors such as exercises and diet have been

*Corresponding author: Email whjun@pku.edu.cn



paid more attention compared to non-modifiable factors such as genetics⁽⁶⁾.

Many individual-level factors related to physical activity (PA), sedentary behaviours (SB) and dietary behaviours have been identified to be determinants of childhood obesity⁽⁷⁾. Familial characteristics such as parental weight status and socio-economic status also play important roles in these processes⁽⁸⁾. Nonetheless, as recognised by the theoretical framework of the ecology of human development⁽⁹⁾, child development is the results of the complex interplay of not only the individual factors but also the environmental factors at multiple levels. Given the children spend regularly much time in the school setting, and the provisions, guidelines, activities and facilities within schools are accessible to all students, school is believed as a key environment to have population-level and long-lasting impact on children's obesity. Indeed, most childhood obesity interventions were school-based⁽¹⁾. However, a systematic review analysed the evidence of school-based intervention for obesity and found mildly effective in reducing BMI among children⁽¹⁰⁾. In order to effectively design and implement obesity prevention strategies in schools, it is necessary to identify which school-level characteristics are related to obesity in students.

For now, a growing number of studies focused on the impact of school-level characteristics on students' obesity-related behaviours. Some studies aimed to identify the association between the built environment and PA in school children and found that the increased accessibility to PA facilities may facilitate the PA level of students^(11,12). Other studies reported that providing more physical education lessons, intramural and interschool programmes also has a favourable effect on improving students' PA level^(13,14). A cross-sectional study conducted in Xi'an, China, also suggested that less extracurricular exercise and sports meeting were related to less PA in adolescents⁽¹⁵⁾. Similar results were observed with respect to food choice of school children. Students' intake of low-nutrient energy dense food and their BMI decreased in schools which followed the nutrition policy and restricted the availability of unhealthy foods⁽¹⁶⁾. However, only a few school-level PA-related characteristics have been found to explain the variance in students' overweight or obesity^(17,18). Even though some evidences in China suggested that school food environment (e.g. cafeterias and campus food stores) was associated with the prevalence of overweight/obesity in schools^(19,20), only a limited number of school-level characteristics were reported in these studies. Some other potential variables, such as school personnel and health management, were not taken into consideration.

The lack of evidence exploring multiple characteristics related to obesity in school environment is still an important gap in the literatures. Hence, in order to provide evidence for prevention and control of childhood obesity in Chinese primary schools, the present study aimed to investigate the broader range of school-level characteristics and to identify

which school-level characteristics are related to obesity with consideration of individual-level characteristics.

Methods

Participants

This cross-sectional study was conducted in primary schools from an urban district and a rural district of Beijing, China from 2015 to 2016. All the public primary schools with at least fifty students at grade 4 were invited to complete the school-based obesity prevention survey. In total, thirty-seven of the forty-three schools (86 %) which meet the inclusion criteria provided the principal approval for the study. In the thirty-seven schools, 2–3 classes were randomly selected from all classes in grade 4 of each school. All the students with their parents' informed consents were enrolled from each selected class. Of the 2480 students enrolled at grade 4 from thirty-seven primary schools, we finally included a total of 2201 students who had no vital organ diseases or disability and provided their parents' informed consents.

Data collection

Outcomes

Anthropometric measurements of students were conducted by the professional team of the district-level Primary and Secondary School Health Center according to the standard protocol⁽²¹⁾. Students were required to wear light clothing and be barefooted when being measured. In order to guarantee the measurement quality and control the measurement error, 3 % of those students were additionally selected randomly to be measured for the second time in each survey day. Weight was measured using the lever weight scale and recorded to the nearest 0.1 kg. Height was measured using the wall-mounted stadiometer and recorded to the nearest 0.1 cm. BMI was calculated as weight divided by height squared (kg/m^2). Obese children were defined according to BMI categories based on International Obesity Task Force criteria for Asian children, and children defined as thin, normal and overweight were classified as non-obese⁽²²⁾.

Individual-level variables

Individual-level variables included student and family variables. Student variables were collected by a self-administered questionnaire. The students completed the questionnaire during school time guided by two trained investigators. The questionnaire included information on sex, age, PA, SB and dietary behaviours. For PA, daily duration of moderate-to-vigorous physical activity was reported based on a validated 7-d Physical Activity Questionnaire⁽²³⁾. Students were also asked whether or not they liked sports very much (Yes or No) as an additional indicator of PA. For



SB, daily duration of watching TV/movies, playing video/computer/iPad/phone and doing homework were reported. Average daily screen time and homework time were classified into ≤ 2 h/d and > 2 h/d separately in accordance to previous studies⁽²⁴⁾. For dietary behaviours, weekly frequencies and servings of vegetables, fruits, meat, milk and sugar-sweetened beverages intakes were investigated with the questionnaire designed based on the validated Block Kids Food Screener⁽²⁵⁾. Students were also asked whether or not they perceived their eating speed is lower than the other students in the class (Yes or No) as an additional indicator of dietary behaviours.

The family variables were collected by asking one of the student's caregivers to complete questionnaire, including the parents' weight, height, education and occupation. Previous studies have demonstrated the validity of self-report weight and height in adults⁽²⁶⁾. BMI was calculated, and categories were defined according to the WHO classification of overweight and obesity for adults⁽²⁷⁾. Family socio-economic status was estimated by Green Score⁽²⁸⁾. Parents' education and occupation were used to calculate the Green score, i.e. $\text{Green Score} = 0.7 \times (\text{father's education} + \text{mother's education}) + 0.4 \times (\text{father's occupation} + \text{mother's education})$, then the level of socio-economic status was classified as low (< 25 th percentile) and average/high (≥ 25 th percentile).

School-level variables

School-level variables were collected with an interviewer-administered school questionnaire, which was initially derived from policies, provisions and guidelines on supporting healthy school environment at national-level and district-level. Questions and themes were developed based on previous studies, that is, the PLAY-Ontario study⁽¹⁴⁾, the Environmental Determinants in Young people (SPEEDY) study⁽²⁹⁾ and the Health Behavior in School-aged Children (HBSC) study⁽²⁴⁾. Prior to data collection, we conducted interviews with experts on school health, administrators at local school health agencies and relevant school staffs to identify the potential key variables according to their experiences regarding obesity prevention strategies. Modifications were also made to the wording and formatting of the questions afterwards.

The final school-level questionnaire involved thirty indicators of five obesity-related themes: (1) School personnel allocation (four indicators): the number, and educational background of school health professionals; position of the responsible person in charge of obesity prevention and control; the management team of obesity prevention. (2) School management policies (seven indicators): written school guidelines; annual work plan; meetings on students' obesity prevention; availability of students' health records; monitoring students' nutrition status; partnership of school sport and health department; participation of class administrators. (3) School health education (nine indicators): health education (e.g. having professional teachers and

curriculum schedule), obesity-related lectures, courses and activities for students; obesity-related educational opportunities, feedback of the annual students physical examination, suggestions for overweight/obese students, and school obesity prevention report for parents; obesity-related educational opportunities for teachers. (4) School PA reported by the head of physical education teacher (seven indicators): duration of PA (e.g. compulsory physical education classes and other physical activities) in regular school time; alternative PA in extreme weather conditions; PA homework in holidays; frequency of intramural sports teams and clubs; school sports meeting; promoting overweight/obesity students' PA involvement; playground equipment like climbing structure and swings, etc. (5) School food environment (three indicators): type of school lunch providers (school canteens or food companies); offering the recipes with food composition to parents; control the overeating of overweight/obese students at school lunch. Each indicator was classified into two categories (Yes or No).

At each school, two trained investigators completed a school-level questionnaire by conducting face-to-face interview with the school health professional, who was responsible for obesity prevention and control. In order to improve the reproducibility of the data, a main investigator took part in data collection of all schools. In order to ensure the reliability and accuracy of the information, plausible answers were asked by investigators to provide more details, or to confirm via relevant school staffs (e.g. school administrators, physical education teachers and health education teachers). Reviewing available documents and field observation were also conducted if required.

Statistical analyses

To take account of the hierarchical data structure (students nested within schools), generalised linear mixed models were used to estimate which school-level characteristics were associated with students' obesity while controlling for potential individual-level variables. Consistent with previous studies, our statistical analyses used three-step modelling procedures^(12,17).

First, the null model was established to determine whether the difference in students' obesity among schools was random or fixed, and the school-level variance term was used to calculate the intra-class correlation for obesity among schools.

Second, a series of univariate multilevel analyses were performed to identify any individual- and school-level variables potentially associated with obesity. In these exploratory models, sex, age and school location (rural or urban) were adjusted as fixed terms with school as a random effect. Each individual- and school-level variable was included one by one, only variables that were statistically



significant at $P < 0.20$ were retained⁽⁴³⁾. After these initial screening stages, a 'school-based obesity prevention index' was calculated as the additive score of retained school-level variables (Yes = 1 point, No = 0 point), with the higher value reflecting the higher quality of school obesity prevention and control. The use of additive score was also found in previous HBSC study⁽¹¹⁾ and COSI study⁽³⁰⁾. Based on the median number, the school-based obesity prevention index was further converted into a dichotomous variable for the following analysis.

Finally, a multivariate model was performed to simultaneously examine how the identified individual-level variables and the school-based obesity prevention index were associated with students' obesity, with adjusting same confounders in the second step. Since cross-level interactions were suggested in the previous study⁽¹⁸⁾, we additionally examined the interaction terms between school- and individual-level variables in the same model. Statistical tests were considered to be significant if two-sided $P < 0.05$. All statistical calculations were performed with SAS software (V9.3; SAS Institute Inc.).

Results

General characteristics of participants

There were 1107 (50.3%) boys and 1094 (49.7%) girls included in our final analysis. The average age of participants was (10.00 ± 0.41) years. The average BMI of participants was 18.20 ± 3.66 kg/m², with 17.2% of them classified as obese.

Potential individual- and school-level variables associated with childhood obesity

The associations of individual-level variables with childhood obesity at $P < 0.20$ are showed in Table 1. Findings from univariate analyses indicated that student variables including liking sports, screen time, homework time,

perceived eating speed, as well as family variables including parental weight status were associated with obesity. Nevertheless, the variables of moderate-to-vigorous physical activity, dietary pattern and family socio-economic status did not show significant effects at $P < 0.20$ and were not included in final analyses (online Supplemental Table S1).

The seven school-level variables which were associated with students' obesity at $P < 0.20$ are showed in Table 2, including one variable from school personnel allocation, two variables from school management policies, two variables from school health education and two variables from school PA. Moreover, one variable was statistically associated with obesity, suggested that students attending a school that reached the national standard of the number of health professionals (at least one health professional every 600 students) were less likely to be obese compared with the others (OR 0.68, 95% CI 0.51, 0.91, $P = 0.010$). The full list of school-level variables which were analysed is provided in online Supplemental Table S2. We further calculated the school-based obesity prevention index for each school (range from 0 to 7 points), which was the cumulative score from these seven school-level variables. According to the median number of 5, eleven schools with 642 students were classified as higher index value and twenty-six schools with 1559 students were classified as lower index value.

The associations of individual-level and school-level variables with childhood obesity

The adjusted OR in the final multivariate model are presented in Table 3. In individual-level, students with screen time ≤ 2 h/d showed the lower prevalence of obese compared with students with screen time > 2 h/d (OR 0.65, 95% CI 0.48, 0.86, $P = 0.003$). It was also lower among students liking sports and having perceived lower eating speed compared with those counterparts, with an OR of 0.34 (95% CI 0.26, 0.43, $P < 0.001$) and 0.45 (95% CI 0.35, 0.59, $P < 0.001$), respectively. The increased risk

Table 1 The individual-level variables associated with childhood obesity ($P < 0.20$)*

Variables	Categories	n	Prevalence of obesity (%)	OR	95% CI	P-value
Student variables						
Liking sports	No	834	26.0	1		
	Yes	1363	11.8	0.32	0.25, 0.41	<0.001
Screen time no more than 2 h/d	No	411	25.6	1		
	Yes	1761	15.3	0.55	0.42, 0.72	<0.001
Homework time no more than 2 h/d	No	614	21.0	1		
	Yes	1569	15.7	0.73	0.57, 0.93	0.011
Lower perceived eating speed	No	476	30.0	1		
	Yes	1717	13.6	0.43	0.34, 0.55	<0.001
Family variables						
Weight status of father	Non-overweight/obesity	1102	11.9	1		
	Overweight/obesity	1099	22.5	2.22	1.75, 2.81	<0.001
Weight status of mother	Non-overweight/obesity	1716	13.5	1		
	Overweight/obesity	485	30.1	3.06	2.38, 3.93	<0.001

*Adjusted for sex, age and school location (rural or urban) with school as a random effect.

Table 2 The school-level variables associated with childhood obesity ($P < 0.20$)*

Variables	Categories	Number of schools	Number of individuals (n 2201)	Prevalence of obesity (%)	OR	95 % CI	P-value
School personnel allocation	No	24	1497	18.6	1		
	Yes	13	704	14.1	0.68	0.51, 0.91	0.010
Reached the national standard of the number of health professionals	No	10	621	19.5	1		
	Yes	27	1580	16.3	0.79	0.58, 1.08	0.141
School management policies	No	25	1480	18.5	1		
	Yes	12	721	14.4	0.76	0.55, 1.04	0.086
Availability of health records of overweight/obese students	No	14	822	19.1	1		
	Yes	23	1379	16.0	0.78	0.59, 1.04	0.095
Monitoring nutrition status of students regularly	No	7	413	20.6	1		
	Yes	30	1788	16.4	0.73	0.51, 1.05	0.087
School health education	No	4	224	21.0	1		
	Yes	33	1977	16.7	0.74	0.46, 1.18	0.199
Providing the health education activities at least eight times (75th percentile) per year	No	13	744	20.2	1		
	Yes	24	1457	15.7	0.75	0.55, 1.01	0.058
Reporting achievements of obesity prevention activities to parents	No						
	Yes						
School physical activity	No						
	Yes						
Duration of physical activity during school time at least 1 h/d	No						
	Yes						
Playground equipment like climbing structure and swings, etc.	No						
	Yes						

*Adjusted for sex, age and school location (rural or urban) with school as a random effect.

was found for the students of paternal overweight/obesity (OR 2.09; 95 % CI 1.63, 2.69, $P < 0.001$) and maternal overweight/obesity (OR 2.77; 95 % CI 2.12, 3.61, $P < 0.001$). In school level, the results suggested that the school-based obesity prevention index was associated with students' obesity. If a student attended a school which had the index value above 5, he/she was less likely to be obese than a student attending a school that had the index value ≤ 5 (OR 0.56; 95 % CI 0.40, 0.79, $P = 0.001$). No statistically significant interactions were found between the individual-level variables and school-based obesity prevention index on obesity, suggesting that the association between school-based obesity prevention index and students' obesity was not moderated by individual-level variables in the present study.

Discussion

We comprehensively investigated a total of thirty school-level variables involving school personnel, management, health education, PA and food environments. We ultimately identified seven variables potentially related to students' obesity and further established the school-based obesity prevention index. Our results suggested that the index was associated with students' obesity after controlling for individual-level variables. Contrary to previous studies which reported only few school-level variables having statistically significant association with obesity, our study not only examined individual effect size of each school-level variable but also created the school-based obesity prevention index to detect accumulative effect. From a public perspective, it is promising to develop effective obesity interventions based on empirical initiatives implemented by primary schools in China.

With respect to the student variables we took into consideration, we found that liking sports was associated with lower odds of being obese. Previous findings also supported that children's activity preferences may have impact on their PA behaviours thereby influence their weight status, suggesting that even if young people with access to environmental resource may not use them⁽¹²⁾. Besides, we observed a positive association between screen time and obesity, whereas the same association has not been observed in other SB time such as homework time. A recent review suggested that screen time and predominantly TV viewing were associated with unhealthy dietary behaviours in children⁽³¹⁾. Meanwhile, longer screen time often implies shorter homework time and PA time due to the daily waking time limit^(4,32). These could be the explanations why the association between screen time and obesity was stronger than other SB time in our results. Finally, a positive association has been seen regarding perceived eating speed and obesity. Ochiai *et al.*⁽³³⁾ also found fast eating speed increased the risk of being overweight compared with medium eating speed. Due to a reduced awareness of

Table 3 The adjusted odds ratios for the individual- and school-level variables associated with childhood obesity*

Variables	Categories	OR	95 % CI	P-value
Individual-level variables				
Student variables				
Liking sports	No	1		
	Yes	0.34	0.26, 0.43	<0.001
Screen time no more than 2 h/d	No	1		
	Yes	0.65	0.48, 0.86	0.003
Homework time no more than 2 h/d	No	1		
	Yes	0.86	0.66, 1.12	0.265
Lower perceived eating speed	No	1		
	Yes	0.45	0.35, 0.59	<0.001
Family variables				
Weight status of father	Non-overweight/obesity	1		
	Overweight/obesity	2.09	1.63, 2.69	<0.001
Weight status of mother	Non-overweight/obesity	1		
	Overweight/obesity	2.77	2.12, 3.61	<0.001
School-level variables				
School-based obesity prevention index	Low index value (≤ 5)	1		
	High index value (> 5)	0.56	0.40, 0.79	0.001

*Adjusted for sex, age and school location (rural or urban) with school as a random effect.

satiety, quickly eating may lead to higher energy intake, eating slowly could also be effective for preventing over-eating and obesity in children⁽³⁴⁾. Regarding family variables, our study showed that childhood obesity had strong association with parental weight status, which could be explained by both genetics and environmental interactions between children and parental weight^(35,36). For example, previous studies found that parental dietary pattern was associated with children's dietary pattern⁽³⁷⁾, and family factors can explain 61 % variance of healthy food intake⁽³⁸⁾. This result supported the idea that school-based obesity intervention with home involvement might be more effective.

It is of particular note that most of the variables in univariate analysis were not statistically significant under significance level of $P < 0.05$ when we explored the associations between school-level characteristics and obesity. The paucity of statistically significant associations has also been seen in previous studies^(17,29). As numerous school-based obesity intervention studies suggested, obesity prevention is a complex task which needs comprehensive programmes involving PA and nutrition⁽³⁹⁾. Single-component strategy such as educational interventions may have limited efficiency in prevention of childhood obesity⁽⁴⁰⁾. In light of the above, our study advances the method to obtain more insights into the impact of school-level characteristics. We observed the cumulative effect of seven school-level factors, indicating that the school-based obesity prevention index above 5 can make a substantial contribution to obesity prevention and to some extents make schools flexible to choose the strategies which are suitable for their own contexts.

Of the school-level factors examined in univariate analysis, the number of health professionals was the only one that had a significantly negative association with the risk of students' obesity. The health professionals play an

important role in students' health since they are not only in charge of the disease control but also undertaking health education, supervision and promotion in Chinese primary schools. According to School Health Regulations from Chinese government, every 600 students need a health professional in primary schools, and if the number of students is < 600 , at least one health professional should be allocated. However, the situation of insufficient personnel is still common even among schools in Beijing, suggesting that it is urgent for stakeholders to improve the quantity of health professionals in primary schools.

In addition to the importance of health professionals in schools, we also found monitoring the nutrition status regularly and having the health records of overweight/obese students had beneficial effects on obesity prevention, which were also undertaken by existing intervention studies as feedback and motivation strategies⁽³⁹⁾. Moreover, our results proved that providing health education activities frequently was one of the predictors, and parental involvement may accentuate the impact in alignment with the evidence of system reviews^(41,42). Furthermore, schools with longer duration of PA may decrease the likelihood of students being obesity. Previous study found that school hours almost contributed to half of total moderate-to-vigorous physical activity in students, supporting that enough PA during school hours may facilitate childhood obesity prevention⁽⁴³⁾. At last, our results also indicated that students' obesity may benefit from better playground equipment. This may be explained by increased PA level when more facilities are available^(24,44). Apart from those factors, we did not observe any variable from food environment under the statistical significance at $P < 0.20$, thereby no variables from this theme were included in the school-based obesity prevention index. However, Li *et al.*⁽²⁰⁾ found the presence of cafeterias was associated with increased overweight/obesity risk in rural middle



school students, and another Chinese study also suggested that having food regulations in school cafeterias and campus food stores were related to lower intake of energy dense foods as well as the prevalence of overweight/obesity in those primary and middle schools⁽¹⁹⁾. The availability of healthy and unhealthy food was also associated with students' nutrition status^(16,45,46). Since we only investigated three indicators about school food environment, further investigative work is required to provide more evidence how the foods offered by schools contribute to students' obesity.

There are some limitations in this study. First, it is a cross-sectional study which does not allow us to infer the causal relationship. However, the evidence of associations is still meaningful for further experimental studies. Moreover, our data were collected in a sample from two districts of Beijing, and only students from grade 4 were included, so the results may not be generalised to the entire population. However, according to the experience of our previous studies, the students at grade 4 can well understand and complete the questionnaire and they have less study pressure influencing their daily behaviours compared with senior students; hence it is a representative group for most students in primary schools. Besides, previous studies suggested that neighbourhood environments surrounding schools are also related to students' obesity⁽⁴⁷⁾. However, this information is unavailable in the present study, and future study should also take school neighbourhood environmental factors into consideration. Finally, our data were based on a questionnaire. But, the school-level questionnaire was completed by trained investigators so that the reliability of data can be ensured. The school questionnaire still needs further validation.

Conclusions

This study reveals that the specific school-level characteristics had cumulative effects on obesity, and several individual-level characteristics were also related to obesity among Chinese primary school children. From a population-level perspective, the prevalence of obesity was lower in schools with the higher school-based obesity prevention index compared with that in schools with the lower index. Further school-based obesity intervention should consider these aspects in particular and evaluate whether both improving the school- and individual-level characteristics would be effective in preventing childhood obesity.

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Supplementary material

For supplementary material accompanying this paper visit <https://doi.org/10.1017/S1368980019004592>.

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