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Cross-national comparison of childhood obesity: the epidemic and the relationship between obesity and socioeconomic status

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Background Obesity has become a worldwide epidemic. Recently WHO acknowledged an urgent need to examine child obesity across countries using a standardized international standard. Studies in adults find obesity and socioeconomic factors (SES) factors are correlated, but results are inconsistent for children. Using an international standard, we examined the prevalence of obesity and compared the associations between SES factors and obesity across countries.

Methods Data for children aged 6–18 from nationwide surveys in the US (NHANES III, 1988–1994), China (1993), and Russia (1992) were used. We used the recently updated US NCHS body mass index (BMI = wt/ht^2) reference to define obesity (BMI $\geqslant$95th percentile) and overweight (85th$\leqslant$BMI<95th percentile). The WHO recommends an early version of the NCHS reference for international use. We conducted logistic analyses to examine the relationship between SES and obesity.

Results The prevalence of obesity and overweight was 11.1% and 14.3%, respectively, in the US, 6.0% and 10.0% in Russia, and 3.6% and 3.4% in China. The relationship between obesity and SES varied across countries. Higher SES subjects were more likely to be obese in China and Russia, but in the US low-SES groups were at a higher risk. Obesity was more prevalent in urban areas in China but in rural areas in Russia.

Conclusions Child obesity is becoming a public health problem worldwide, but the prevalence of obesity varies remarkably across countries with different socioeconomic development levels. Different SES groups are at different risks, and the relationship between obesity and SES varies across countries.

Keywords Child, adolescent, obesity, overweight, socioeconomic status, cross-national comparison

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Obesity has become a global epidemic, and it is still increasing in both industrialized and developing countries.[1] For example, the prevalence of child obesity and overweight has doubled in North America during the past two decades. At present, about one-quarter of children in the US are obese or overweight.[2] In Thailand, a transitional society, the prevalence of obesity in schoolchildren has increased from 12% in 1991 to 16% in 1993.[3] Due to the difficulty of curing obesity in adults and the many long-term adverse effects of childhood obesity, the prevention of child obesity has been recognized as a public health priority.[4] Increasing evidence shows that childhood obesity has a profound influence on morbidity and mortality in adult life.[4–6] However, few studies have examined the worldwide situation regarding childhood obesity, particularly due to the fact that no standard or reference is agreed upon internationally. Different definitions have been used in studies to define childhood obesity.[1,4,7,8] Recently a World Health Organization (WHO) consultation on obesity concluded, 'The current lack of consistency and agreement between different studies over the classification of obesity in children and adolescents makes it difficult to give an overview of the global prevalence of obesity', and an examination of obesity in children and adolescents across the world based on a standardized obesity classification system is urgently needed.[1]

The literature has another major gap because a large number of studies on adults have examined the relationship between

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socioeconomic status (SES) factors and obesity, but less research has used data representing large populations to examine the effects of these relationships on children.[9–12] Sobal and Stunkard have provided an excellent review of this topic.[11] After examining over 140 published studies, they concluded that these studies reveal a strong inverse relationship between SES and obesity among women in developed societies, but the relationship is inconsistent for men and children. In contrast, in developing countries a strong relationship exists between SES and obesity among men, women, and children. It is of concern, however, that since different obesity definitions and SES indicators were used, the findings in different studies may not be comparable.

Moreover, it is argued that how SES and obesity are related is not clear. Among adults it is likely that causality operates in either direction.[13–15] We expected that it may be easier to test the direction of such a causality with studies among children because usually the SES of children is determined by their parents' characteristics instead of being influenced by their own obesity status and the related social consequences. To our knowledge, limited efforts have been made to systemically examine the relationships between childhood obesity and SES across countries using large-scale survey data.

Our main objective is to examine the current cross-continental situation of child and adolescent obesity and compare the relationship between SES factors and obesity across countries using an international obesity standard. We include industrialized and developing countries from different continents and with different socioeconomic development levels.[16,17] Nationwide survey data collected in the early 1990s from the US, China, and Russia are used. The national total population was 1244 million in China, 268 million in the US, and 147 million in Russia in the early 1990s; and their total populations account for over a quarter of the global population.[18]

Materials and Methods

Subjects

Children and adolescents aged 6–18 years who had complete anthropometric and demographic data from national surveys in each country were included. Pregnant girls were excluded. The final sample size was 6110 for the US; 3028 for China; and 6883 for Russia.

Data sources

The Third National Health and Nutrition Examination Survey (NHANES III, 1988–1994)

The third NHANES was a cross-sectional representative sample of the US civilian, non-institutionalized population aged ⩾2 months. NHANES III contains data for a sample of 33 994 people, and it oversampled blacks, Mexican Americans, children under 5 years, and the elderly (⩾60 years). Detailed descriptions of the sample design and operation of the survey have been published elsewhere.[19] Standardized protocols were used for all interviews and examinations. Data on weight and height were collected for each individual in the full mobile examination centre through direct physical examinations. Based on self-reported race and ethnicity, subjects were classified into non-Hispanic white, non-Hispanic black, Mexican American, and other four ethnic groups.

The China Health and Nutrition Surveys (CHNS, 1993)

The CHNS covered eight provinces that vary substantially in geography, economic development, public resources, and health indicators. Anthropometric measurements were carried out by trained health workers, who followed standard protocol similar to the US NHANES protocol developed by the US National Center for Health Statistics (NCHS). Weight was measured in light indoor clothing to the nearest tenth of a kilogram with a beam balance scale. Height was measured without shoes to the nearest tenth of a centimetre using a portable stadiometer. Detailed descriptions of the CHNS have been published elsewhere.[20] The 1993 data were used. The CHNS time frame matches that of US NHANES III.

The Russian Longitudinal Monitoring Survey (RLMS, 1992)

The RLMS is the first nationally representative household survey in the Russian Federation. All members of more than 6400 households from all regions of Russia were surveyed eight times from 1992 to 1998. Weight and height were measured to follow a protocol similar to the ones used in the NHANES III and CHNS surveys. Detailed descriptions of the RLMS have been published elsewhere.[21] The 1992 data were used for a better comparison (i.e. similar survey year) with data from the US and China.

Measures

Definition of obesity and overweight

Adiposity was measured by using the body mass index (BMI = weight [kg]/height [m]^2). Following WHO's recommendation, we used a series of sex-age-specific BMI cut-offs to define obesity and overweight.[22] It is important to choose a good obesity standard for examining the global obesity epidemic and making international comparisons.[1,4,7,8] A WHO Expert Committee recommends using a set of sex- and age-specific BMI percentiles, developed by Must and others based on the US NHANES I data collected in 1971–1975, to define adolescent obesity, overweight, and underweight.[22–24] Specifically the WHO recommends using the BMI 85th percentile to define overweight and the 5th percentile for underweight. This reference is called the 'WHO/NCHS reference',[22] and it has been widely used in the US and other countries.[4,8,25–29] Although the WHO Expert Committee recommends using both the BMI 85th percentile and the triceps skinfold thickness 90th percentile to define adolescent obesity,[22] this has been used infrequently due to the difficulty of measuring triceps skinfold thickness in large population-based studies (e.g. our RLMS data). Instead, many have recommended the use of the BMI 95th percentile to define child and adolescent obesity.[23,24,29,30]

Most recently the US NCHS updated the old WHO/NCHS reference by using new data and better statistical techniques,[30] although the new BMI cut-offs are similar to the previous ones. It is expected that this new reference will be accepted to replace the old WHO/NCHS reference for international research. Therefore we chose to use the new NCHS BMI cut-offs. The sex-age-specific BMI 85th, and 95th percentiles were used to define overweight, and obesity respectively. Also, because the prevalence of obesity is very low in China, in our comparison analysis we focused on overweight.

An alternative that we have considered is the recently published 'IOTF standard' proposed by the Childhood Obesity Working Group of the International Obesity Task Force (IOTF).[7,31] Our previous analysis showed that in general the

WHO/NCHS and IOTF references produced similar estimates of overall overweight prevalence, although the differences are noticeable for certain ages.[32] In addition, recently some concerns have been raised regarding the use of the IOTF standard, except for its strengths.[32,33] Our decision to use the WHO/NCHS reference allows easier comparisons between our findings and those of others who have used this reference.

Sociodemographic characteristics

Subjects were separated into two age groups: children (6–9 years) and adolescents (10–18 years). Self-reported urban-rural residences were used. As a result the meanings of urban and rural residences may vary across countries. Per capita family income tertiles were used to indicate low, middle, and high SES. Family income data were collected at the same time children's BMI measurements were collected.

Statistical analysis

First, we examined the prevalence of overweight and underweight in each country by age group, sex, urban/rural residence, and SES. For the US, to achieve national representative prevalence estimates, sampling weights were used to adjust for sample design effects. Next, using logistic regression models, we examined the associations between obesity and SES for each country. Since the prevalence of obesity was low in China and Russia, we combined obesity and overweight (i.e. BMI ⩾85th percentile). Furthermore, we examined the associations between BMI and SES. For the US, in all regression analyses, sample design effects were adjusted, and the effect of ethnicity was also examined. All analyses were performed by using SAS Version 6.12 (SAS, Cary, NC, USA) and Stata Version 6.0 (Stata Co., College Station, TX, USA).

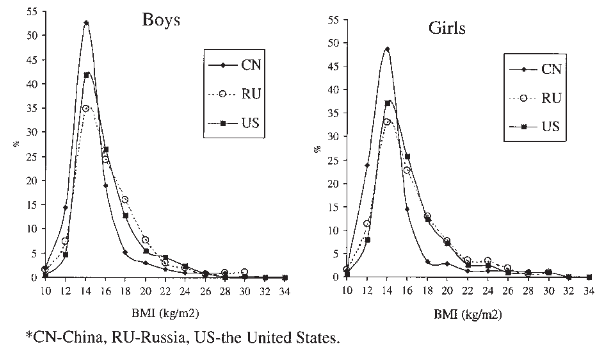

Figure 1 Body mass index (BMI) distribution among children (6–9 years) in the US, Russia and China: by sex

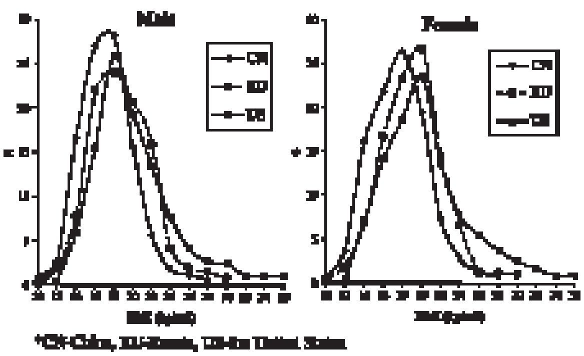

Figure 2 Body mass index (BMI) distribution among adolescents (10–18 years) in the US, Russia and China: by sex

Results

Children and adolescents' main characteristics and BMI distribution in each country

Each sample's main sociodemographic characteristics are summarized in Table 1. On average American and Russian children and adolescents were taller and heavier than their Chinese counterparts. We also examined the distribution of BMI among children and adolescents in each country (Figures 1 and 2). A clear shift of increased BMI existed across the three countries. The trends were more obvious among adolescents than among children.

Table 1 Main characteristics of each sample

	US	Russia	China
Years of data collection	1988–1994	1992	1993
Sample size	6110	6883	3028
Age (years)	12.4 (5.4)[a]	12.9 (3.7)	12.5 (4.0)
Female (%)	48.6	51.5	47.6
Urban (%)	47.6	70.9	23.5
Height (cm)	150.6 (3.7)	149.3 (19.2)	140.8 (19.4)
Weight (kg)	47.6 (4.8)	44.3 (15.4)	36.3 (13.9)
BMI[b] (kg/m^2)	20.0 (5.6)	19.3 (3.8)	17.6 (3.4)

[a] Mean (SD).

[b] Body mass index.

The prevalence of overweight and obesity across countries

As shown by Figure 3, the overall prevalence of obesity and overweight was high in the US (combined prevalence was 25.4%), low in China (combined prevalence, 7.0%), and moderate in Russia (combined prevalence, 16.0%). These clearly suggest that national socioeconomic development levels influence the epidemic of obesity. The prevalence of obesity and overweight and the combined prevalence of obesity and overweight by age, sex, and SES groups are presented in Table 2. In the US,

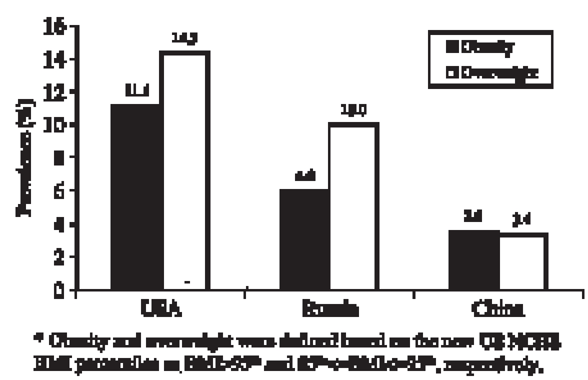

Figure 3 Overall prevalence of obesity and overweight in the US, Russia and China

Table 2 Prevalence (%) of obesity and overweight among children and adolescents in the US, Russia, and China[a]

	US			Russia			China		
	Obese	Overweight	Obese or overweight	Obese	Overweight	Obese or overweight	Obese	Overweight	Obese or overweight
Children (6–9 years)									
All	12.0	12.4	24.4	13.7	16.8	30.5	7.3	4.6	11.9
Boys	11.4	13.7	25.1	13.9	19.5	33.4	6.8	5.9	12.7
Girls	12.7	11.0	23.7	13.5	14.0	27.5	7.9	3.1	11.0
Rural	12.1	10.7	22.8	16.4	18.0	32.4	6.1	4.4	10.5
Urban	11.9	14.2	26.1	12.3	17.3	29.6	11.4	5.2	16.6
Low-income	12.1	11.1	23.2	14.5	17.7	32.2	7.6	3.4	11.0
Medium-income	11.1	11.9	23.0	13.8	14.2	28.0	8.1	3.7	11.8
High-income	13.2	15.0	28.2	12.3	20.7	33.0	5.9	7.9	13.8
Adolescents (10–18 years)									
All	10.7	15.2	25.9	3.2	7.4	10.6	1.8	3.0	4.8
Boys	11.7	14.0	25.7	4.5	7.0	11.5	1.8	3.0	4.8
Girls	9.7	16.4	26.1	2.0	7.7	9.7	1.8	3.0	4.8
Rural	11.2	16.0	27.2	3.2	10.1	13.3	1.6	2.8	4.4
Urban	10.2	14.2	24.4	3.2	6.3	9.5	2.5	3.5	6.0
Low-income	14.0	18.7	32.7	3.1	9.4	12.5	2.1	2.7	4.8
Medium-income	11.9	13.6	25.5	4.0	5.1	9.1	0.9	2.5	3.4
High-income	5.5	13.5	19.0	2.8	8.0	10.8	2.6	4.0	6.6

[a] Obesity was defined as body mass index (BMI) ⩾95th percentile, overweight, 85th⩽BMI<95th percentile, Obese or overweight, BMI ⩾85th percentile.

the prevalence of obesity and overweight among American adolescents was lowest in the high-income group. By contrast, in China the high-income groups generally were at a higher risk of obesity. The prevalence of obesity was higher in rural areas in Russia but higher in urban areas in China. Interestingly, in both Russia and China, but not in the US, the prevalence of obesity and overweight was higher among children than among adolescents. The differences were especially remarkable for obesity.

Comparison of relationships between obesity and SES across countries

Socioeconomic status was related to children's and adolescents' risks of being obese or overweight (simply termed 'obese'), although the relationships were different across countries (Table 3). In Russia urban children and adolescents were at a lower risk of obesity, but in China urban children and adolescents were at a higher risk. Compared to the medium-income group, the low-income group was at a higher risk in both the US and Russia, and in Russia the high-income group was also at an increased risk. In China, however, high-income children and adolescents were more likely to be obese. Moreover our analysis stratified by gender indicates that in both China and Russia (but not the US), boys and girls are at different risks even if they have the same SES (Table 4). That is, gender is an effect modifier.[34]

Sobal and Stunkard suggested that research was needed to examine whether the relationships change with age in children and adolescents.[11] We tested the relationship between SES and obesity by age group (6–9 years and 10–18 years) for each country, and then by each year of age for American children and adolescents. We found that similar significant associations between obesity and SES existed in both age groups in China and Russia. By contrast, in the US only among adolescents (age ⩾10 years) did we find a reverse relationship between SES (i.e. income) and obesity. Low-income adolescents were at a higher risk for obesity (OR = 1.4, 95% CI : 1.1–1.9), and high-income adolescents were at a lower risk (OR = 0.7, 95% CI : 0.5–0.9). The SES was not significantly related to obesity among children under 10 years. The association became significant only among adolescents at age 12, and it became insignificant at age 17.

Table 3 Comparison of relationship between obesity and socioeconomic status across countries: OR and 95% CI[a]

	US	Russia	China
Age (⩾10 years)	1.1 (0.9–1.3)	0.3 (0.2–0.3)*	0.4 (0.3–0.5)*
Female	1.0 (0.8–1.2)	0.8 (0.7–1.0)	0.9 (0.7–1.2)
Urban	1.0 (0.8–1.3)	0.8 (0.7–0.9)*	1.5 (1.1–2.0)*
Low-income	1.3 (1.01–1.6)*	1.4 (1.2–1.7)*	1.2 (0.8–1.7)
High-income	0.8 (0.7–1.1)	1.2 (1.0–1.4)*	1.5 (1.0–2.1)*

[a] Combined overweight and obesity, defined as body mass index ⩾85th percentile. Logistic regression analysis.

* $P < 0.05$.

Table 4 Relationships between obesity and socioeconomic status by sex: odds ratio and 95% CI[a]

	Russia		China	
	Male	Female	Male	Female
Urban	0.9 (0.7–1.1)	0.7 (0.5–0.8)*	2.1 (1.4–3.2)*	0.9 (0.5–1.4)
Low-income	1.2 (0.9–1.5)	1.7 (1.4–2.2)*	1.0 (0.7–1.7)	1.3 (0.8–2.2)
High-income	1.0 (0.8–1.2)	1.6 (1.2–2.0)*	1.3 (0.8–2.2)	1.6 (0.9–2.8)

[a] Combined overweight and obesity, defined as body mass index ⩾85th percentile. Logistic regression analysis. Age was adjusted. For the US, when stratified by gender none were statistically significant ($P > 0.05$).

* $P < 0.05$.

Moreover, for the US consistent with many previous studies, we found that ethnicity was a significant risk factor. Compared to whites, blacks and Mexican American children and adolescents were at a higher risk for obesity and overweight; OR were 1.2 (95% CI : 1.01–1.5) and 1.4 (95% CI : 1.1–1.9), respectively. Age and gender were adjusted. However, when income and urban-rural residence were adjusted, ethnicity became insignificant. These may suggest that the SES differences across ethnic groups are likely the main explanation for the difference in obesity prevalence across ethnic groups. We could not examine these ethnic/subculture variations in China and Russia because minorities only count for a small proportion of their total populations. In both the Russia and China surveys, only a very small proportion of the subjects are from minority ethnic groups. The small sample sizes did not allow us to conduct meaningful comparisons.

Finally, we examined BMI as a continuous variable, stratified by sex and age groups. In general, results (Table 5) were consistent with the logistic regression analysis. High-income American girls had lower BMI. In Russia urban girls had lower BMI, but low- and high-income groups had higher BMI. In contrast, in China urban boys had higher BMI. Also SES effects seemed to vary by age groups. In the US, for example, although low-income was not a significant risk factor for elevated BMI among children under 10 years, it was a strong one among adolescents (age $\geqslant$10 years). For the US we also examined the influence of ethnicity. Interestingly, African-American girls and Mexican-American girls were more likely to have a higher BMI than white girls even when controlled for family income and urban/rural residence ($P < 0.05$). The regression coefficients and SES were 0.87 (0.27) and 0.84 (0.39), respectively. For males, however, ethnicity was not a significant risk factor ($P > 0.05$). In addition, since the distribution of BMI in each sample was slightly skewed, we repeated the regression analyses using natural logarithms transformed BMI. The results we found were similar.

Table 5 Relationships between body mass index and socioeconomic status stratified by sex and age: regression coefficients (β) and SE[a]

	Male			**Female**		
	β	SE	*P*-value	β	SE	*P*-value
US						
All						
Urban	–0.03	0.24	0.900	0.03	0.22	0.876
Low-income	0.48	0.30	0.117	0.42	0.25	0.105
High-income	0.01	0.37	0.976	–0.66	0.26	0.013
6–9 years						
Urban	0.03	0.19	0.887	0.03	0.23	0.881
Low-income	0.48	0.20	0.200	0.31	0.24	0.202
High-income	–0.39	0.21	0.073	0.05	0.36	0.886
10–18 years						
Urban	–0.01	0.22	0.981	–0.06	0.20	0.782
Low-income	0.42	0.22	0.060	0.61	0.21	0.006
High-income	–0.44	0.28	0.117	–0.39	0.24	0.121
Russia						
All						
Urban	–0.21	0.13	0.131	–1.20	0.13	0.000
Low-income	–0.29	0.16	0.068	1.05	0.14	0.000
High-income	–0.28	0.14	0.054	0.54	0.14	0.000
6–9 years						
Urban	0.06	0.27	0.826	–0.41	0.30	0.172
Low-income	0.15	0.35	0.667	0.90	0.36	0.012
High-income	–0.26	0.28	0.357	0.16	0.31	0.608
10–18 years						
Urban	–0.30	0.16	0.059	–1.47	0.14	0.000
Low-income	–0.42	0.18	0.016	1.11	0.15	0.000
High-income	–0.26	0.17	0.115	0.74	0.15	0.000
China						
All						
Urban	0.64	0.17	0.000	0.09	0.20	0.641
Low-income	0.31	0.17	0.066	0.30	0.19	0.119
High-income	0.32	0.19	0.086	0.14	0.21	0.520
6–9 years						
Urban	0.68	0.35	0.049	0.69	0.40	0.081
Low-income	0.42	0.34	0.217	–0.29	0.37	0.445
High-income	0.22	0.40	0.580	–0.01	0.43	0.992
10–18 years						
Urban	0.62	0.19	0.001	–0.12	0.22	0.577
Low-income	0.24	0.19	0.193	0.58	0.22	0.009
High-income	0.56	0.20	0.006	0.20	0.24	0.397

[a] Multiple linear regression analysis. Age was controlled for as a continuous variable.

Discussion

The lack of consistent classifications in various studies makes it difficult to assess the global situation of child and adolescent obesity.[1–8] To our knowledge, our study is the first attempt to examine child and adolescent obesity across countries using an international standard and based on data from large nationwide surveys. Overall we found that the prevalence of obesity differs remarkably across countries with different socioeconomic development levels. The combined prevalence of obesity and overweight was high in the US (25%), moderate in Russia (16%), and low in China (7%). Even though the use of different standards makes comparisons of findings difficult, previous studies indicate that in many other developed countries child and adolescent obesity have reached levels comparable to those in the US.[1,35–37] In addition evidence suggests that the prevalence of overweight has increased to relatively high levels in many developing countries.[1] For example, in Brazil the prevalence of overweight among schoolchildren has tripled and increased from 4% in the 1970s to 14% in late 1990s. In 1997, 17% of children and 13% of adolescents were obese or overweight in 1997.[38] In Egypt 14% of adolescents were overweight or obese in 1997.[25] Worthy of mention, there are still controversies over the use of a series of universal BMI cut-offs to define obesity or overweight in different populations of either adults or children.[22,32,33,39] For example, it was recently suggested that different BMI cut-offs should be used for Asian and Caucasian populations.[33] Nevertheless, our results clearly show that childhood obesity is becoming a worldwide epidemic. The remarkable variation in the prevalence across populations suggests that social, economic, and environmental factors are important influences on the epidemic, although it maybe also true that genetic differences across populations also play a role.[5]

Our analysis shows that child and adolescent obesity is related to SES, although the relationships differ among these three populations. We used family income as a primary indicator of SES, while rural-urban residence might serve as an additional indicator. In the US low SES groups had a higher risk of obesity. By contrast, in China high SES groups were at an increased risk. In Russia, a transitional society that has experienced economic difficulties since the early 1990s,[21,40] both low-income and high-income groups were at an increased risk of obesity compared to the medium-income group. One possible explanation for the different SES-obesity relationship in developed countries such as the US and developing countries such as China is that the influence of SES on people's lifestyles such as diet and physical activity may differ. Take food consumption patterns as an example. In China richer people have better access to meat and other energy-dense foods (which are much more expensive than other foods such as vegetables) than the poor.[26] While in the US, higher-SES groups usually consume more vegetables and fruits, which are less energy-dense, than low-SES groups.[41]

Unlike China, where urban children were more likely to be obese, in Russia urban groups were less likely to be obese than were rural groups. In the US no consistent rural-urban difference emerged. Similar to the results for China, the recent Egyptian national survey found that the prevalence of overweight and obesity was 22.6% among urban adolescents versus 10.4% among rural adolescents.[25] These patterns are particularly attributable to the differences in people's access to food and health services, physical activity patterns, and social norms in rural and urban areas in these countries. Compared to their rural counterparts, urban Chinese usually have higher family income, better access to food (especially meat and poultry), public services such as health care and transportation. They are also more likely to have sedentary lifestyles.[26,42] In contrast, US rural and urban children and adolescents have similar access to food choices thanks to the well-established food production and distribution system. They are also likely to have similar lifestyles.[43] In Russia, urban groups were less likely to be obese than rural groups. This is probably due to that in the past decade, living standards of urban groups have been seriously affected by the socioeconomic difficulties occurring since the collapse of the former Soviet Union.[16,17,21,40] Furthermore, our analysis stratified by sex and age further indicate that social, economic, and environmental factors may operate through complex pathways to influence childhood obesity.

In general our findings regarding the relationships between obesity and SES are consistent with findings from many previous studies.[10,11,25,44] For example, among the 32 studies conducted on girls from developed societies reviewed by Sobal and Stunkard,[11] 40% found a inverse relationship between SES and obesity, although 25% found a positive relationship and 35% found no relationship. The results were similar for boys. The majority of the 16 studies conducted among children from developing societies indicate a clear positive relationship.[11] Most recently McMurray and others also found that low SES influenced adolescents' body weight status in the US.[44] EI-Tawila and others found that in Egypt the prevalence of obesity among high SES adolescents was more than double that among low SES groups (7.0% versus 3.1%).[25]

Another interesting finding is that in both Russia and China but not in the US the prevalence of obesity and overweight was higher among children than among adolescents. The differences were especially remarkable regarding obesity. Further research is needed to investigate whether the gap is due to the differences in children's and adolescents' social and behavioral factors, such as diet and physical activity, or if it is because of the WHO/NCHS standard, which is based on data from the US. For example, it has been well documented that thinness is desired in many developed societies, such as the US, and dieting is popular among young American females.[45,46] However, 'the biological picture is not accurately reflected in American popular culture'.[46] In other words, the growth patterns of American children and adolescents are not necessarily the optimal patterns for other populations. Furthermore, ample evidence suggests that sexual maturation is related to being fat, and adolescents in many developing countries mature later than their American counterparts.[22,47] Therefore we suspect that by using the WHO/NCHS standard we might have underestimated the obesity problem among adolescents in China and Russia.

Our study has several limitations. Although the NHANES III and the RLMS samples are nationally representative, the CHNS sample is not. Only 8 of China's 31 provinces are covered. China is a country with large heterogenities.[26,42] The CHNS sample can not reflex the whole situation in China. Since the CHNS study, however, was designed to monitor nationwide trends, provinces of different geography, economic development, public resources, and health indicators have been included. And, in each province, communities of different SES levels were sampled. Thanks to the close collaboration from local health officials and nutritionist, plus the support of participants, the non-participation rate was very low whenever the subjects were identified and invited to participate in the 1993 survey. Hence, we are confident that the CHNS sample can provide good insights into the SES and obesity relationship in China. In addition, a common weakness of the data sets we used is that information about children and their care-providers' attitudes and values toward obesity and children's physical activity patterns (except for the US sample) were not collected. As a result, we could not make a further investigation about how SES may influence obesity nor to make more comprehensive comparisons among the three countries. Finally, this is a cross-sectional study. We could not prove any causal relationship.[34] Nevertheless, our findings provide some important insights into the child and adolescent obesity problem.

In conclusion, obesity is becoming a public health problem influencing children and adolescents in both developed and developing countries. The prevalence of obesity varied remarkably across countries with difference socioeconomic development levels, while within a certain population different SES groups are at different risks. To effectively fight the global obesity epidemic, population-based social and environmental approaches should be considered.

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KEY MESSAGES

- Using an international standard, we studied childhood obesity and the associations between socioeconomic status (SES) factors and obesity in the US, Russia and China.
- The prevalence of obesity (including overweight) varies remarkably across the three countries of different socioeconomic development levels: 25% in the US, 16% in Russia, and 7% in China.
- Different SES groups are at different risks, and the relationship between obesity and SES varies across countries.

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Commentary: Globalization and the epidemiology of obesity

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The biomedical roots of epidemiology lead most epidemiologists to examine individuals as units of analysis, typically in one population and one place, and to interpret their findings using physiological explanations. However, comparative epidemiology is increasingly contrasting the prevalence and patterns of various conditions in different places, and social epidemiology is employing social science interpretations of research findings.

Like many other fields, epidemiologists are paying close attention to the rise in the prevalence of obesity in all parts of the world in what has been labelled the 'obesity epidemic'.[1,2] Much epidemiological research has examined high levels of adult obesity, and now more analysts are studying children's body weights to seek the precursors of overweight adults and examine future adult cohorts.

Research by Wang[3] in this issue of the *International Journal of Epidemiology* advances current knowledge about obesity in children by applying standardized consensus-based measures of body weight to relatively recent cross-sectional samples in three large nations: China, Russia, and the US. Comparative cross-national research designs[4] may provide useful insights about processes involved in the changing prevalence of health conditions such as body weight. Wang[3] found obesity and overweight were relatively common in US children while underweight was rare, the reverse was true of China, and Russia stood between the other two nations. Wang[3] also identified important variations in overweight and underweight by socioeconomic status and rural-urban residence, which suggested additional complexities in the processes underlying body weight differences between the three nations. Wang's[3] research opens the door for epidemiologists to incorporate the concept of globalization into the field.

Cross-national data can be interpreted in several ways, including as evidence of globalization.[4] Epidemiologists have typically considered national differences in health and illness as site-specific cases or as examples of a progressive modernization process that nations proceed through at different rates. Rather than considering each nation as a separate unit of analysis, however, an alternative is to consider the world as a global unit where overarching institutions and processes operate. Such global thinking has emerged as an important framework in the social sciences,[5] and it would be fruitful for epidemiologists to incorporate globalization into their conceptualizations and analyses. Little global thinking is currently evident in epidemiology, with some exceptions in considering globalism in occupational health, infectious disease, and nutrition.[6]

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Globalization is the process of worldwide integration and unification of previously local, national, and regional phenomena into global units. Globalization involves more than internationalization or cross-national, cross-cultural, or cross-population linkages. Achievement of globality makes nations components of a common global whole rather than separate units of analysis to be compared independently. Global governments, global corporations, global media, global food systems, and global diseases become the new units of analysis rather than separate national, local, or individual cases. To the extent that obesity represents a worldwide epidemic, it constitutes a global pandemic rather than a set of independent occurrences in various nations. The crucial point in thinking about globality is that global conditions have underlying global causes and also require global interventions.

Global increases in the incidence and prevalence of obesity are grounded in the globalization of Western post-industrial food systems and consumer culture that has increasingly penetrated all societies of the world.[5,7] Understanding the global epidemiology of obesity requires analysis of the global institutions that modify caloric intake and energy expenditure. Global corporations are establishing industrialized agro-food systems in almost all nations that will provide constant 24 hours a day/7 days a week/365 days a year consumer access to virtually unlimited volumes of relatively inexpensive calorifically dense foods to all people in all places at all times through supermarket, catering, vending, takeout, home delivered, drive through, and fast/snack foods.[8,9] Other global processes provide increasingly universal and relatively inexpensive transportation, communication, and other activity-sparing systems through automobiles, television, and energy-saving components of the built environment that minimize physical activity levels for a growing proportion of people worldwide.[8,9] Global food systems and global vehicles, appliances, and mass media are the underlying causes of increases in global obesity.[6,9]

To fully understand the globalization of obesity, epidemiologists need to move beyond biology and beyond behaviours to examine collective social, economic, and political structures and cultural changes rather than focusing only on individual physiology and personal characteristics. Global values, corporations, and politics transform the material conditions of life so that children and adults eat more and are less active, leading to global increases in obesity. Including questions on national surveys that ask about processed food consumption and television viewing can provide insights into the underlying processes in the globalization of obesity better than additional batteries of standard demographic and health questions. Investigation of globalization may also employ multi-level contextual analyses, examining neighbourhood or national fast food franchises and obesity levels or analysing television access in communities and mean body weights.

Some nations such as the US are almost completely globalized in their food and activity patterns for all social strata. Other countries like Russia and China are currently less than fully globalized, where higher socioeconomic status individuals have become incorporated into global systems and are becoming obese while lower socioeconomic status individuals remain localized and experience undernutrition. Rural-urban differences in obesity are small in the US,[3,10] where globalization approaches universal penetration, while they remain large in countries such as China and Russia where rural locations have not been as completely drawn in to global systems. Children and adolescents tend to participate in global culture more quickly than their parents, and therefore young cohorts bear watching for their involvement in global institutions that will shape their eating and activity levels and consequently their body weights.

The biomedical basis of epidemiology has led the field to focus on comparisons of individuals and populations, rather than units more appropriate to analysis of globalization such as markets or cultures. The usefulness of epidemiological data is contingent upon providing information about appropriate units. Obesity interventions sometimes include local and national policy changes,[2,6] but global rather than community and federal public health measures are needed to adequately deal with the globalization of obesity.

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