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Geographic variation in the prevalence of overweight and economic status in Chinese adults

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China is experiencing a rapid increase in overweight and related conditions. This study describes the geographic variation in BMI levels and the prevalence of overweight and underweight in Chinese adults, and assesses their relations with regional Gross Domestic Product (GDP) per capita levels. BMI values and the prevalence of overweight and underweight in 143 522 adults from the Chinese National Nutrition and Health Survey (2002) were calculated according to geographic regions in China. Their correlations with GDP were assessed. Linear and logistic regressions were used to adjust for age, sex and city–country composition. BMI and the prevalence of overweight were highest in the Bohai coastal regions while lowest in southern provinces such as Guangdong, Guangxi, Yunnan, Hunan and Fujian. Mean BMI values ranged from 20·72 to 25·48 kg/m^2, and the prevalence of overweight ranged from 6·6 to 53·9 %. BMI and the prevalence of overweight were positively correlated with economic development, particularly in the northern regions. However, for regions with similar GDP per capita levels, those in the south had substantially lower BMI and lower prevalence of overweight than those in the north. Interestingly, some southern regions with high GDP per capita had low BMI and low prevalence of overweight. The prevalence of underweight was highest in the south. Substantial geographic variations in the prevalence of overweight and underweight exist in China. Such variations cannot be fully explained by the differences in economic status. China is currently facing challenges of both overweight and underweight but priorities vary in different regions.

Overweight: Geographic variation: Underweight: Economic status: Chinese

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China is experiencing a rapid increase in overweight and obesity[1–4], which coincides with the recent impressive economic development. With a huge population base, mainland China has thirty-one provinces, autonomous regions and municipalities characterized by geographical and economic diversity. BMI is a commonly used measurement of overweight and underweight. Rural and urban differences in the prevalence of overweight and obesity have been well demonstrated in China[4]. Further understanding the geographical distributions of BMI and the prevalence of overweight and underweight in China is important for planning regionally tailored intervention strategies to reduce the health risks associated with overweight as well as underweight. Maps are powerful tools with which to study the spatial distribution of a health condition. Particularly, they are useful for demonstrating regional variation[5].

The Chinese National Nutrition and Health Survey was conducted in thirty-one administrative regions (provinces, autonomous regions and municipalities) in mainland China in 2002[6,7]. Comprehensive data on dietary, lifestyle, and anthropometric and biochemical measurements were collected. The survey had multiple objectives to understand the nutritional status and chronic disease risk factors in mainland China. The objectives of the present study were to describe the geographic variation in BMI levels and prevalence of overweight and underweight in Chinese adults using the data from Chinese National Nutrition and Health Survey, and to assess the relations of BMI and overweight with the regional Gross Domestic Product (GDP) per capita levels.

Methods

Participants

The sampling procedures of the Chinese National Nutrition and Health Survey in 2002 have been described elsewhere[6]. The survey involved a stratified multistage randomized sampling method, covering 132 survey sites in thirty-one geographic regions (provinces, municipalities or autonomous regions). All adults in the selected households were included and those living in institutions were excluded. The overall participation rate was estimated as about 90 % at the planning

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Abbreviation: GDP, Gross Domestic Product.

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stage and the actual number of participants was higher than originally planned[6]. Since the original survey was designed to select representative samples from six economic levels (strata) in China, region-specific participation rates were not known. Chongqing municipal region was regrouped into Sichuan province due to the closeness of geographic locations and the similarity in BMI levels. In the present study, we included 143 522 adults (80 689 women and 62 833 men) aged 20–79 years. The numbers of study participants in the final thirty regions are shown in Table 1. Except Hainan province and Tibet autonomous region with relatively small numbers, each of the other regions had more than 1800 participants.

Variables

Body height and body weight were measured according to standardized procedures[8]. Training on anthropometric assessment was provided at the beginning of the survey. Height was measured to the nearest 0·1 cm while weight was measured with study participants in light indoor clothes and without shoes to the nearest 0·1 kg. BMI was calculated as weight (kg)/height (m^2). The WHO's cut-off points for BMI were used to define overweight as BMI $\geq$ 25 kg/m^2 which includes both pre-obese (BMI 25–29·99 kg/m^2) and obese (BMI $\geq$30 kg/m^2), and underweight as BMI $<$ 18·5 kg/m^2[9]. Although different cut-off points have been suggested to define individuals of an increased risk for Asian populations[10], we used the commonly used BMI $\geq$ 25 kg/m^2 as overweight for the purpose of comparison.

Regional GDP per capita (from the National Bureau of Statistics of China) in 2001, the year before the survey was conducted, was used as an indicator of standard of living and economic status.

Data analysis

Crude means and 95 % CI of BMI were calculated according to regions. In the original survey, the samples were not designed to represent the geographic regions[6]. The study samples from the thirty geographic regions differed in age and sex distributions, and also differed in city and country population compositions. Because of the city–country disparities in body weight and body height[3] and the differences in city–country population ratios among different regions, it is critical to adjust for city–country compositions when comparing BMI levels among the geographic regions. Therefore, we used multiple linear regressions to adjust for age, sex and city–country variables and to calculate the adjusted differences in BMI values.

Region-specific prevalence of overweight and underweight were calculated. To obtain adjusted OR for overweight, we used the variable overweight as the dependent variable, geographic regions as independent variables, and age, sex, and city–country as potential confounders to establish a logistic regression model. Similarly, we calculated adjusted OR for

Table 1. Numbers of study participants, mean BMI, and prevalence of overweight and underweight by regions in mainland China

	Total number	Female (%)	Mean age (years)	BMI		Overweight (%)	Underweight (%)
				Mean	SD		
Guangxi	2969	57·7	44·6	20·72	2·62	6·6	17·9
Jiangxi	3177	55·2	43·1	21·07	2·55	7·4	12·9
Guangdong	8332	56·8	45·8	21·52	3·16	14·3	15·8
Hunan	5039	56·2	44·1	21·72	2·89	12·7	10·6
Fujian	3126	55·5	43·3	21·86	2·82	13·7	9·1
Yunnan	5058	57·6	42·2	22·03	3·03	15·7	9·6
Guizhou	5165	55·0	43·4	22·31	3·10	17·7	7·1
Qinghai	2062	61·1	43·4	22·57	3·22	21·1	7·9
Anhui	4288	55·9	45·9	22·61	3·23	20·9	7·1
Hubei	6616	56·9	42·6	22·79	3·24	22·8	6·4
Sichuan	10 140	57·6	46·0	22·81	3·21	23·3	6·1
Zhejiang	4611	54·3	44·2	22·81	3·21	23·7	6·8
Shaanxi	8358	57·7	44·4	22·97	3·21	24·4	5·5
Inner Mongolia	2377	56·9	41·6	23·11	3·19	24·9	4·3
Hainan	957	59·9	45·4	23·32	3·43	31·4	6·6
Henan	9646	54·6	44·5	23·34	3·35	28·5	4·7
Xinjiang	1828	53·4	40·5	23·43	3·62	29·5	4·9
Jiangsu	8687	57·1	45·1	23·46	3·35	29·1	4·3
Jilin	2553	53·9	43·4	23·48	3·35	30·6	5·0
Ningxia	1830	54·9	42·6	23·50	3·34	31·3	4·5
Gangsu	3324	57·6	44·0	23·53	3·00	29·0	3·0
Shanghai	3801	55·9	50·4	23·69	3·45	34·0	5·8
Heilongjiang	3545	56·3	42·4	23·70	3·76	34·0	5·3
Shanxi	6885	54·6	44·1	23·73	3·17	31·3	3·4
Tibet	850	67·3	45·9	23·90	3·99	35·1	7·4
Liaoning	7913	55·9	46·5	24·09	3·51	37·0	3·6
Hebei	6989	54·4	43·9	24·19	3·53	37·5	2·9
Shandong	7187	55·9	45·7	24·65	3·63	43·6	2·6
Tianjin	2205	56·1	48·1	24·98	3·77	47·5	3·0
Beijing	4004	56·0	48·6	25·48	3·77	53·9	2·3
Total	143 522	56·2	44·7	23·11	3·44	26·9	6·4

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underweight. All analyses were conducted using Stata Release 10 (Stata Statistical Software, StataCorp LP, College Station, TX, USA). Summary values of regional mean BMI values were transferred into the Epi Info/Epi Map, which were used to display those data as a choropleth map.

Results

Age and sex of study participants by regions

Table 1 shows the numbers of study participants by regions. There were more women than men in all regions, ranging from 53·4 % women in Xinjiang to 67 % in Tibet. About 56 % of the total participants were women. The regional average ages of study participants ranged from 40·5 years in Xinjiang to 50·4 years in Shanghai. The participants from big cities such as Shanghai (50·4 years), Beijing (48·6 years) and Tianjing (48·1 years) were generally older than those from other regions. The differences in age and sex distributions among regions suggest the importance of taking such differences into consideration when comparing BMI levels and prevalence of overweight and underweight among the regions.

Mean BMI and Gross Domestic Product by regions

Mean BMI values and prevalence of overweight and underweight by regions are shown in Table 1. There was a huge geographic variation in mean BMI values among different regions, ranging from 20·7 kg/m^2 in Guangxi to 25·5 kg/m^2 in Beijing (Fig. 1). Some regions had relatively high GDP per capita such as Guangdong, Fujian and Zhejiang, but the BMI levels in those regions were low. To examine the geographic distributions of BMI, the regional BMI values were mapped to their corresponding boundaries on the map of mainland China. As shown in Fig. 2, Beijing and the Bohai coastal regions (Tianjin, Hebei, Shandong and Liaoning) had higher BMI levels while the southern regions such as Guangxi, Jiangxi, Guangdong, Hunan and Fujian had lower BMI levels although some of them were among high GDP regions (Guangdong and Fujian).

According to 2001 regional GDP data, east coast (including Bohai coast) regions had higher GDP levels while non-coast regions had lower GDP levels. However, the BMI levels followed a different pattern with the highest among Bohai coast, followed by north-east and north-west. As mentioned earlier, the southern provinces had the lowest BMI levels.

Prevalence of overweight and underweight

Beijing and Bohai coast regions had the highest prevalence of overweight, followed by the northern regions of China, while the southern regions had the lowest prevalence of overweight (Table 1). The prevalence of overweight ranged from 6·6 % in Guangxi to 53·9 % in Beijing. We also divided the regions into two groups by the Yangtze River: southern and northern regions. Figure 3 shows the relations between GDP levels and the prevalence of overweight. There are two interesting points. First, for the regions with similar GDP per capita, the northern regions tended to have higher prevalence of overweight than their southern counterparts. Second, the correlation between GDP and the prevalence of overweight

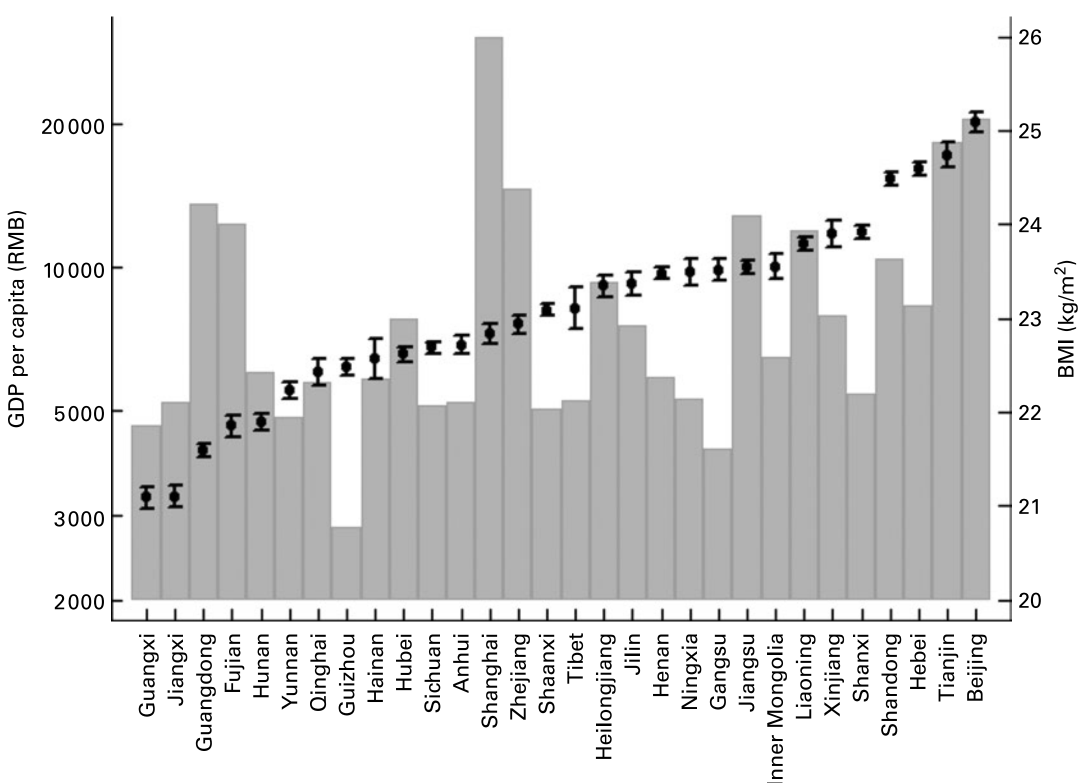

Fig. 1. BMI (●) and Gross Domestic Product (GDP) per capita by regions in mainland China. BMI values are means with 95 % CI depicted by vertical bars. RMB, Renminbi (currency of the People's Republic of China).

Fig. 2. BMI kg/m^2 in adults by regions in China. □, Missing or excluded; ▪, 20·00–20·99; ▪, 21·00–21·99; ▪, 22·00–22·99; ▪, 23·00–23·99; ▪, 24·00–24·99; ■, ≥25·00. The South China Sea (Nan Hai) Islands are not shown on this map. The boundaries are only indicative and may not be accurate.

in the north (r 0·871; 95 % CI 0·660, 0·955) was stronger than that in the south (r 0·489; 95 % CI −0·056, 0·809). As expected, the prevalence of underweight was highest among the regions with low BMI, such as Guangxi, Jiangxi, Guangdong, Fujian and Yunnan.

OR and differences

Adjusting for age, sex and city–country variables did not alter the differences among regions (Table 2). There were up to 4 kg/m^2 differences in adjusted BMI, and the odds for overweight in the highest prevalence region was about ten times as high as that in the lowest region (OR 10·7; 95 % CI 9·1, 12·6). The OR for underweight was as high as 7·4 (95 % CI 5·9, 9·4) for the highest region comparing to the lowest region.

Discussion

Substantial geographic variations in the BMI levels and the prevalence of overweight and underweight exist in China. Such variations cannot be fully explained by the difference in the economic status. Generally, the northern regions tend to have higher BMI and higher prevalence of overweight, particularly in the Bohai coastal regions. The southern regions, including some with relatively higher GDP provinces such as Guangdong and Fujian, tend to have lower BMI and lower prevalence of overweight but higher prevalence of underweight.

After adjusting for age, sex and city–country variables, the mean BMI in highest region was 4 kg/m^2 higher and the odds of overweight was about ten times as high as the lowest region. Therefore, the differences in age, sex and city–country population composition are unlikely to be used to explain the geographic variation. Previous studies have described the differences in body weight and BMI between city and country areas in China[3,4,7]. The differences between northern and southern Chinese have also been reported[11]. A relatively

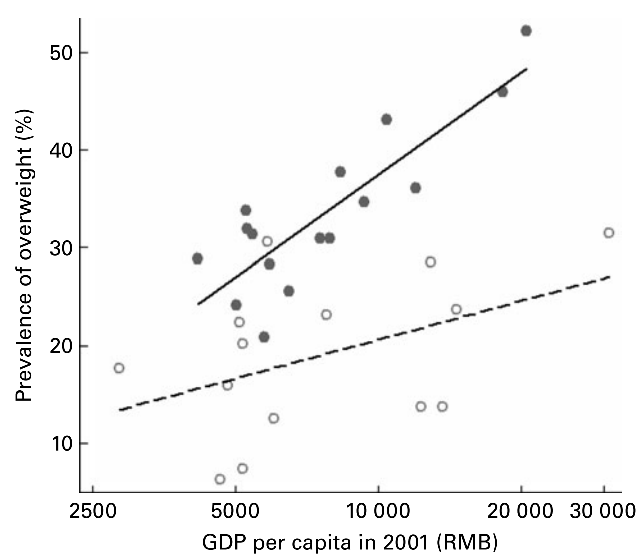

Fig. 3. Prevalence of overweight and Gross Domestic Product (GDP) per capita in mainland China. ●, North; ○, south. RMB, Renminbi (currency of the People's Republic of China).

Table 2. Differences in BMI and OR for overweight and underweight in Chinese adults

	Adjusted BMI*†		Adjusted OR*			
			Overweight†		Underweight‡	
Region	Difference	95 % CI	OR	95 % CI	OR	95 % CI
Guangxi	0		1		7·4	5·9, 9·4
Jiangxi	0·02	−0·15, 0·18	0·9	0·7, 1·1	5·9	4·7, 7·5
Guangdong	0·50	0·37, 0·64	1·9	1·6, 2·3	7·1	5·7, 8·8
Hunan	0·80	0·66, 0·95	1·8	1·5, 2·1	4·4	3·5, 5·6
Fujian	0·76	0·60, 0·93	1·8	1·5, 2·1	4·0	3·2, 5·2
Yunnan	1·13	0·99, 1·28	2·4	2·0, 2·8	4·0	3·2, 5·1
Guizhou	1·39	1·25, 1·54	2·7	2·3, 3·1	2·9	2·3, 3·6
Qinghai	1·34	1·15, 1·52	2·7	2·3, 3·3	3·6	2·8, 4·7
Anhui	1·62	1·47, 1·78	3·1	2·6, 3·7	2·8	2·2, 3·6
Hubei	1·53	1·39, 1·67	3·0	2·6, 3·5	3·0	2·4, 3·8
Sichuan	1·60	1·47, 1·73	3·1	2·7, 3·6	2·6	2·1, 3·3
Zhejiang	1·85	1·70, 2·00	3·8	3·2, 4·5	2·8	2·2, 3·5
Shaanxi	2·00	1·87, 2·14	3·9	3·4, 4·6	2·2	1·7, 2·7
Inner Mongolia	2·46	2·28, 2·63	5·0	4·2, 6·0	1·6	1·2, 2·1
Hainan	1·48	1·24, 1·72	3·3	2·7, 4·1	3·8	2·8, 5·3
Henan	2·39	2·26, 2·53	4·9	4·2, 5·7	1·9	1·5, 2·3
Xinjiang	2·81	2·62, 3·00	6·5	5·5, 7·8	1·8	1·4, 2·5
Jiangsu	2·46	2·32, 2·59	4·9	4·2, 5·7	1·7	1·3, 2·1
Jilin	2·27	2·10, 2·44	4·7	3·9, 5·5	2·2	1·7, 2·9
Ningxia	2·40	2·21, 2·59	5·2	4·3, 6·2	1·9	1·4, 2·6
Gangsu	2·43	2·27, 2·59	4·6	3·9, 5·4	1·2	0·9, 1·7
Shanghai	1·75	1·59, 1·91	3·5	3·0, 4·1	3·2	2·5, 4·2
Heilongjiang	2·25	2·09, 2·41	4·8	4·1, 5·6	2·7	2·1, 3·4
Shanxi	2·83	2·69, 2·97	5·9	5·0, 6·9	1·3	1·0, 1·6
Tibet	2·02	1·77, 2·27	3·9	3·2, 4·8	4·3	3·1, 6·0
Liaoning	2·70	2·57, 2·84	5·6	4·8, 6·5	1·6	1·3, 2·1
Hebei	3·50	3·36, 3·64	8·9	7·6, 10·4	1·0	0·8, 1·3
Shandong	3·40	3·26, 3·54	8·1	6·9, 9·4	1·1	0·8, 1·4
Tianjin	3·65	3·47, 3·83	9·0	7·6, 10·7	1·3	0·9, 1·7
Beijing	4·00	3·84, 4·15	10·7	9·1, 12·6	1	

* Adjusted for age, sex and city–country variables.
† Guangxi as reference.
‡ Beijing as reference.

small sample study using data from three regions shows that the Chinese in the north (Beijing and Shanxi) have higher blood pressure and BMI than those in the south (Guangxi)[11]. In the present study, we used the unique data collected from all geographic regions in mainland China to describe the detailed geographic variation in BMI and the prevalence of overweight and underweight. Importantly, we examined the relation between economic status and the prevalence of overweight at the population level.

The regional variation in the prevalence of overweight has also been reported in other populations. Scarborough and Allender found that there are clear geographical differences in the prevalence of overweight and obesity in England[12]. After adjustment for sex, age and social class, the OR for overweight in their study was between 1·1 and 1·2 for men and women in the period 1998 to 2004[12]. Comparing with their finding, the geographic variations in China as shown in the present study are much greater with the OR of the highest to the lowest regions reaching as high as 10·7 (95 % CI 9·1, 12·6) although the two studies may not be directly comparable because different sets of confounding variables were included.

There are several potential implications of the present findings. They can be useful for policy makers and health professionals in their efforts (1) to develop region-specific intervention strategies, (2) to understand the regional variation of other chronic conditions such as diabetes, hypertension and CVD, and (3) to guide future research to identify risk factors, particularly modifiable risk factors, contributing to the geographic variations. The present data show that China is facing both challenges of overweight and underweight, but the priorities differ among geographic regions. Another interesting point is that a mean BMI itself may not be able to capture the complete picture of nutritional problems in a region. For example, although Tibet had a similar mean BMI as Shanxi and Liaoning, the prevalence of underweight in Tibet was more than double that in the other two provinces. Therefore, when we assess nutritional problems in a region, both BMI levels and BMI distributions should be carefully assessed.

Accompanying the rapid economic development in the recent years, China is experiencing an increase in the occurrence of obesity[1–4] and related conditions such as diabetes[13]. Economic development results in an abundance of food and alteration of lifestyles. However, the geographic variations in BMI levels and the prevalence of overweight and underweight do not parallel the economic levels among regions. With similar economic status, the northern regions tend to have a higher prevalence of overweight than their southern counterparts, indicating the existence of other causes.

We propose several possible explanations for geographic variations. Firstly, there are fifty-six ethnic groups in China residing in different regions. In the present study, the majority of the study participants were from the Han ethnic group in all regions except Guangxi, Xinjiang and Tibet. Even within the Han ethnic group, people from different regions may differ genetically. Secondly, climate variety among regions may also play a role in determining both lifestyles and diets. For example, the winter in the northern city of Harbin is long and cold with average temperature below 0°C from November to March. The local residents may often stay indoors and consume high-energy food during winter time. On the other hand, the residents in the subtropical city Guangzhou in the south with monthly average temperatures above 13°C are likely to perform more outdoor activities all year round. Thirdly, the most important explanation perhaps is the difference in the lifestyle and dietary factors because of differences in customs and in access to and cost of various types of food among regions. The north produces more wheat, while rice cultivation predominates in the south. The energy and protein intake is generally higher in the north than in the south[14]. Further identifying detailed dietary and lifestyle factors that cause the regional variation can be helpful for reducing overweight and obesity, particularly in the current high-risk regions. Further research is needed to investigate why the southern regions have a low prevalence of overweight even if they have higher economic status.

One strength of the present study is the large sample size with complete coverage of all regions in mainland China, with the participants from all thirty-one provinces, autonomous regions and municipalities. Another strength is that we took the differences in age, sex and city–country composition among regions into consideration in our analysis. Several limits of the present study should be acknowledged. Since the survey was not originally designed for geographic regional comparisons, the sample from each region may not be truly representative of the overall population in the region. In the present study, although we have documented geographic variation in BMI levels and the prevalence of overweight and underweight, the real causes are still not clear. A vast amount of information has been collected in the Chinese National Nutrition and Health Survey, including detailed dietary and lifestyle measurements[6]. Using these data, we will further analyse the possible factors associated with the geographical variations, including genetic, environmental, dietary and lifestyle factors.

In conclusion, substantial geographic variations in BMI levels and the prevalence of overweight and underweight exist in China. Such variations cannot be fully explained by the differences in economic status. Detailed geographic variations in the prevalence of overweight and underweight can be useful for policy makers to develop tailored interventions for different regions. The present findings underscore the need for continued research of population-based data for the purpose of explaining geographic differences in overweight and underweight in China. Better understanding of why some southern regions with high economic levels have a low prevalence of overweight may provide other regions with some potentially useful and practical approaches for lowering the prevalence of overweight and related health conditions.

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