Original Article

The impact of urbanization on the community food environment in China

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Background and Objectives: Research on how urbanization has influenced the food environment in China is limited. The study aimed to examine the impact of urbanization on the food environment in China. **Methods and Study Design:** Longitudinal data collected during 1989-2009 from the China Health and Nutrition Survey were used, which covered 9 provinces in China. Urbanicity index (0-10) was assessed using an urbanicity scale. Final analyses included 216 communities. Random-effect models were used in analyses. **Results:** Urbanization (higher urbanicity index) increased the odds of having fast food restaurants (OR=2.78, 95% CI: 2.18-3.54) and other indoor restaurants (OR=2.93, 95% CI: 2.28-3.76) within the community, the odds of having supermarkets (OR=2.43, 95% CI: 2.04-2.89) and free markets (OR=2.56, 95% CI: 1.77-3.70) within 30 minutes' bus ride from the community. Food prices for apples (β=0.06, 95% CI: 0.04-0.08) and lean pork (β =0.02, 95% CI: 0.01-0.03) increased with urbanicity, while prices for other food did not. Urbanicity was positively associated with community norms for fast food consumption (RR=1.28, 95% CI: 1.22-1.33), fast food preferences (RR=1.09, 95% CI: 1.06-1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01-1.03). **Conclusions:** Urbanization is associated with food environment in China. The findings provide insight for future economic development and public health efforts related to urbanization.

Key Words: urbanization, food environment, fast food, policy, China

INTRODUCTION

Urbanization has been taking place in many developing countries although it is at a faster rate in some countries compared with others, which likely has many impacts on people's behaviors and health. China has been undergoing urbanization at an accelerating pace in the past three decades. The level of urbanization, as illustrated by the proportion of urban dwellers, rose from less than 20% in 1978 to almost 50% in 2009.[1] This has brought dramatic changes to both the environment and to individuals' lifestyles as well as health outcomes in China. For example, physical activity (PA) levels of Chinese adults declined by a third between 1991 and 2006, especially occupational PA due to changes in the work structure.[2,3] About half of the decline could be explained by urbanization factors, including dynamics in the housing infrastructure, sanitation and availability of higher education institutions.[2]

Changes in the environment and lifestyles induced by urbanization entail new health challenges for the country, in particular the rising epidemic of obesity and chronic diseases.[4,5] China is undergoing a rapid nutrition transition with dual burdens of both under-nutrition and over-nutrition.[6-8] Prevalence of obesity and other non-communicable diseases (NCDs) have been increasing.[4] National data shows that at present approximately one third of Chinese adults and 10 to 20% of children are either overweight or obese; about 20% of adults have hypertension or dyslipidemia;[4,9] and the prevalence of diabetes among men and women aged 20 and above from 14 provinces and municipalities in China reached nearly 10% in 2007-2008.[8] The prevalence of overweight and obesity among Chinese school children increased from less than 2% in 1985 to 15% in 2010.[10] The situation in the most urbanized, metropolitan areas was even worse, with rates of childhood obesity comparable to those in developed countries. A nationally representative survey

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of school- age children in China reported that in 2010, almost one third of boys and one fifth of girls were either overweight or obese in the most urbanized, large coastal cities, while the rate was over 30% among both male and female youths in the United States, as shown by reports from the National Health and Nutrition Examination Survey (NHANES) in 2011-2012.[10-12] The prevalence of diabetes among Chinese adults living in urban areas was found to be doubled than that of rural areas.[13]

It is crucial to examine the impact of urbanization on food environment, which shapes people's diet and health profile.[14-18] However, there have been limited studies focusing on the impact of urbanization on food environment in China;[14,19] and few studies have assessed what aspects of urbanization are more deleterious.

The classification and measurement of the obesogenic environment remains to be a controversial issue. The ANGELO (ANalysis Grid for Elements Linked to Obesity) framework proposed by Swinburn, partitioned the obesogenic environments into four different parts: the physical environment, economic environment, socio-cultural environment and political environment.[20] Such an approach makes it easier to measure and define the obesogenic environment, and will be used in the current study.

This study investigated the impact of urbanization on food environment in China using nationwide longitudinal survey data, and further explored such association by different aspects of urbanization. We focused on three different dimensions of the food environment from the ANGELO framework: (1) local food environment as a feature of the physical environment; (2) community-level food prices as a key feature of the economic environment; and (3) community norms of nutrition knowledge, fast food preferences, and fast food consumption levels as key features of the community-level socio-cultural environment.

MATERIALS AND METHODS

Study design, data and sample

This study used a nationwide, longitudinal dataset from the China Health and Nutrition Survey (CHNS), which started in the year 1989 until most recently. For the physical and socio-cultural environment, we used data collected in 2004, 2006 and 2009, as questions related to most of those two components were not included until 2004. Meanwhile, we included food prices with all waves, as this information was gathered in waves dating back to 1989. CHNS is an ongoing, household-based, open-cohort survey using a multi-stage, random cluster sampling scheme. It has covered nine provinces across China, including Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guizhou and Heilongjiang, thus representing a wide range of geographic and socio-demographic regions in China. The community survey was largely reported by community heads or salespersons.[21,22]

The geographical unit of analysis was urban or suburban neighborhoods and/or rural villages. The average size of neighborhood and/or village in this study ranged from 10.21 to 19.20 square kilometers, and the range of population size was 4,384 to 5,538 per geographical unit.

Our study protocol was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) and the University at Buffalo IRB.

Outcome variables: measures of food environment

This study used three different dimensions of obesogenic food environment as defined in the ANGELO framework, including the physical, economic, and socio-cultural environment.[20]

(1) The physical environment was the local food environment, taking into account four different types of food retail and service establishments: fast food restaurants (mostly Western franchises, e.g. McDonalds, KFC), other indoor restaurants, supermarkets, and free markets (open-air markets). It also incorporated three types of indicators: availability, density and proximity. Availability was defined as whether there were any food establishments in the neighborhood (for fast food or other indoor restaurants), or within 5 kilometers (approximately 30 minutes' bus ride) from the neighborhood (for supermarkets and free markets). Density was defined as the number of food establishments per square kilometer, or per 1,000 residents. Proximity was defined as distance to the nearest food establishment in kilometers. This information was obtained from community leaders with questions like: "*How many supermarkets or hypermarkets are within 5 kilometers of this village/ neighborhood?"*

(2) The economic environment was operationalized as community-level food prices. They were collected from vendors or salespersons. Free market prices were used. If free market prices were not available, large store prices were used. Food items included those commonly consumed by Chinese adults and children, including prices for grains (rice, unbleached flour), oils (rapeseed oil, soybean oil, peanut oil, cottonseed oil), vegetables, fruits (apples, oranges), meat/poultry/egg products (lean pork, chicken, beef, mutton, fish, eggs), dairy products (fresh milk) and soft drinks (Coca-Cola, Jianlibao).

(3) The socio-cultural environment was measured by community norms of nutrition knowledge, Western fast food preferences and consumption based on available data collected from children. They were aggregated from individual children's responses from each community. A sample question was: "*During the past 3 months, how many times have you eaten at a Western fast food restaurant, such as McDonald's or Kentucky Fried Chicken?"* Indicators used included the mean score of nutrition knowledge for all participating children in the community, prevalence of children preferring fast food, and prevalence of children who had consumed fast food over the prior three months. We chose to include only community norms among children rather than adults for the powerful peer influence on children's dietary behaviors.

Independent variables: urbanicity index

In this study, we used a continuous urbanicity index rather than an urban-rural dichotomy. We modified a previously published urbanicity scale developed based on the

CHNS data, which exhibited great measurement quality.[23] The previous urbanicity scale included twelve elements, while we removed two elements: the traditional and modern markets, considering they were highly correlated to our main study outcomes - the food environment.

Our modified urbanicity scale included ten elements, each with a score range from 0 to 10: population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services (see Appendix A for more details). Data for each element was retrieved from the CHNS community survey and thus reported by community heads or salesperson. The final urbanicity index (range 0-10) was obtained by taking an average of the sum score of the ten elements.

Our factor analysis showed that the modified urbanicity scale was uni-dimensional, and had a high test-retest reliability across waves (correlation coefficient r=0.84 to 0.92). Its test-retest reliability was higher in consecutive waves than in non-consecutive waves. Results from item-scale correlations analyses showed moderate to high item-scale correlation (r=0.47 to 0.89). The generated urbanicity index can distinguish the four official designations well, with urban neighborhoods obtaining the highest scores, followed by towns, suburbs and villages, indicating good criterion-related validity (Figure 1). Furthermore, kappa coefficients indicated low to moderate agreement (kappa=0.04 to 0.26) while Spearman correlation coefficients indicated high agreement (r=0.68 to 0.74).

Covariates

Study wave (year), study wave × urbanicity interactions and province were included as dummy variables in our models.

Statistical analysis

Analyses were conducted using STATA 11.[24] Descriptive statistics in wave 2004, 2006 and 2009 were displayed and were compared across waves.

Multi-level logistic regressions, with a random intercept and an unstructured covariance matrix were used to examine the effect of urbanization on the availability of four types of food retail and service establishments: fast food restaurants, other indoor restaurants, supermarkets and free markets in wave 2004, 2006 and 2009. The general model was shown as below:

$$\text{logit}(y=1)_{t,i} = \beta_{0,i} + \beta_1 \times \text{urban}_{t,i} + \beta_2 \times \text{wave}_t + \beta_3 \times \text{province}_i + \beta_4 \times \text{wave}_t \times \text{urban}_{t,i}$$

Where i=community i, t=wave t;

Three different models were fit. The first model used only the urbanicity index as a predictor, while the second model also controlled for study wave and province. The third model used the ten elements of the urbanicity index as predictors. Variance inflation factor indicated no problem with multi-collinearity.

Due to over-dispersion and a large number of zero observations, we used zero-inflated negative binomial regressions with generalized estimating equation (GEE) to examine the effect of urbanization on food density, proximity, as well as the average nutrition knowledge, the prevalence of fast food consumption and fast food preferences. The first model showed the crude association, while the second model controlled for study wave and province.

For community norms of nutrition knowledge, GEE with robust variance estimation were used, adjusting for study wave and province using data from wave 2004, 2006 and 2009.

For community-level food prices, random-effects models were used with jackknife estimation for standard errors, adjusted for study wave and province, using data from wave 1989 to 2009.

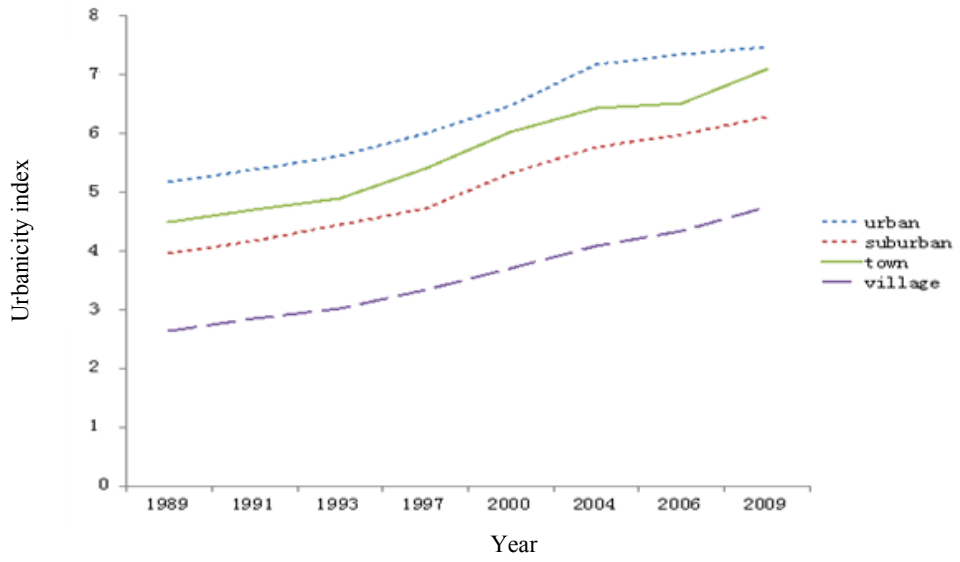

Figure 1. Over-time change in urbanicity index across waves by official designation (residence) in nine provinces in China during 1989-2009[†‡]. [†]Based on data collected from the China Health and Nutrition Survey during 1989-2009. The urbanicity scale includes 10 components: population density, economic activities, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services. The potential sum score can range from 0 to 10. Higher scores indicate greater levels of urbanicity. [‡]Official designation includes urban, suburban, town and villages. This definition was obtained from those at baseline (1989).

RESULTS

General community characteristics and changes in food environment

The number of communities investigated in 2004, 2006 and 2009 was 216, 217 and 217, respectively. Community follow-up was more than 90%. Communities ranged from 10.21 to 19.20 square kilometers, containing 4,364 to 5,338 residents, and from 1,249 to 1,407 households (Table 1).

The average urbanicity index (range: 0-10) increased from 5.26 (SD: 1.58) in 2004 to 5.85 (SD: 1.52) in 2009. Tests to examine the trend in food environment found a significant decline in density of other indoor restaurants, supermarkets, free markets, better proximity to free markets, and greater availability of fast food restaurants (from 16.9% in 2004 to 24.4% in 2009). Prices increased for all food items except jianlibao, a local soft drink brand. Prevalence of fast food consumption and fast food preferences increased significantly, from 19.1% to 27.1%, and 44.8% to 47.7%, respectively, between 2004 and 2009 ($p< 0.05$); while scores in nutrition knowledge did not change significantly.

Validation of urbanicity scale with official designations

Index scores obtained from the modified urbanicity scale showed great agreement with the official designation of urban, suburban neighborhoods, towns and villages in 1989 (Figure 1). Urban neighborhoods scored the highest in urbanicity index, followed by towns and suburban neighborhoods, while rural villages scored the lowest in urbanicity index. Meanwhile, all four types of neighborhoods/villages showed a parallel increasing temporal trend in the urbanicity scale.

Association between urbanization and the physical food environment

Availability

Table 2 shows that after adjusting for study wave, study wave×urbanicity interactions and province, a one unit increase in the urbanicity index accounted for increased odds of the availability of fast food restaurants (OR=3.23, 95% CI: 2.08-5.00), other indoor restaurants in the community (OR=3.04, 95% CI: 2.15-4.30), as well as increased odds of supermarkets (OR=2.34, 95% CI: 1.77-3.08) and open-air free markets (OR=2.88, 95% CI: 1.39-5.97) within 30 minutes' bus ride from the community. Results were similar for models with no adjustments for covariates (results not shown here).

Further analyses indicated a significant positive effect of population density (OR=1.37, 95% CI: 1.10-1.70), sanitation (OR=1.34, 95% CI: 1.08-1.66), health infrastructure (OR=1.31, 95% CI: 1.12-1.52) and economic activity (OR=1.23, 95% CI: 1.07-1.43) on fast food restaurant availability; and a significant positive effect of communication (OR=1.29, 95% CI: 1.01-1.64), health (OR=1.18, 95% CI: 1.05-1.33) and social services (OR=1.24, 95% CI: 1.08-1.43) on other indoor restaurant availability. Furthermore, there was a significant positive effect of communication (OR=1.26, 95% CI: 1.02-1.55), health infrastructure (OR=1.21, 95% CI: 1.09-1.34), economic activity (OR=1.11, 95% CI: 1.01-1.22) and education/income diversity (OR=1.34, 95% CI: 1.02-1.77) on supermarket availability; and a significant positive effect of communication (OR=1.53, 95% CI: 1.07-2.18) on free market availability.

Density

Table 3 reveals a positive effect of urbanization on the density (# per square kilometers) of all four categories of food establishments (adjusted OR=3.69, 3.04, 2.38 and 2.05 for fast food restaurants, other indoor restaurants, supermarkets and free markets, respectively). For each one unit increase in the urbanicity score, the expected number of fast food restaurants per square kilometer within a community increased by 2.7 times, after controlling for study wave, study wave × urbanicity interactions and province. The patterns were less obvious when using number per 1,000 residents as indicators of density.

Proximity

Table 3 illustrates a significant shorter distance to supermarkets (RR=0.59, 95% CI: 0.50-0.70) and free markets (RR=0.54, 95% CI: 0.47-0.62) with increased urbanicity.

Association between urbanization and the socio-cultural food environment

Table 3 reveals a positive association between urbanicity and community norms for fast food consumption (RR=1.28, 95% CI: 1.22-1.33), fast food preferences (RR=1.09, 95% CI: 1.06-1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01-1.03) in children.

Association between urbanization and the economic food environment (food prices)

Table 4 shows that price for most commonly eaten rice (exp(β)=1.01, 95% CI: 1.01-1.02), unbleached flour (exp(β)=1.02, 95% CI: 1.01-1.03), most commonly eaten vegetables (exp(β)=1.08, 95% CI: 1.04-1.11), apples (exp(β)=1.06, 95% CI: 1.05-1.08) and lean pork (exp(β)=1.02, 95% CI: 1.01-1.03) increased significantly with urbanicity, while prices for other food items did not. Interactions between study wave and urbanization were not found ($p>0.05$).

DISCUSSION

This study found that urbanization was associated with changes in all the four dimensions of the community food environment (fast food restaurants, other indoor restaurants, supermarkets, and open-air free markets). With increased urbanization, food retail and service establishments became more available, existed in greater density, and were more accessible (within a shorter walking distance) for residents. Food prices did not change significantly, except in the case of slightly increased prices for rice, unbleached flour, vegetables, apples and lean pork in more urbanized communities. With increased urbanization, children became more knowledgeable about nutrition; but they preferred and consumed more fast food.

We originally hypothesized that more urbanized areas had better access to modern food related market outlets such as supermarkets and restaurants, but had poorer access to traditional markets such as open-air free markets based on some related findings in the U.S.[25-28] However, we found that more urbanized areas had better access to

Table 1. Characteristics of sampled communities and changes in the food environment from 2004 to 2009 in China: CHNS 2004-2009[†]

	Survey wave, mean (SD)		
	2004 (n=216)	2006 (n=217)	2009 (n=217)
Community characteristics			
Population in community	5002 (6089)	4364 (7249)	5338 (9098)
Area size of community (km^2)	16.1 (77.6)	19.2 (73. 8)	10.2 (53.4)
Household number in community	1249 (2592)	1286 (1401)	1407 (1456)
Urbancity index (0-10)	5.27 (1.58)	5.48 (1.56)	5.85 (1.52)
Neighborhood by community type, n (%)			
Urban neighborhood,	35 (16.2)	36 (16.6)	35 (16.1)
Suburban neighborhood	37 (17.1)	37 (17.1)	37 (17.1)
Town neighborhood	36 (16.7)	36 (16.6)	37 (17.1)
Rural village	108 (50.0)	108 (49.8)	108 (49.8)
Physical food environment			
Density (no. per 1,000 residents)			
Fast food restaurants	0.14 (0.65)	0.10 (0.45)	0.04 (0.15)
Other indoor restaurants	3.82 (7.77)	3.35 (5.70)	2.88 (5.21)*
Supermarkets	2.23 (5.20)	1.14 (3.66)*	0.85 (1.86)*
Free markets	2.45 (5.25)	1.27 (1.89)*	1.03 (1.42)*
Density (no. per square kilometer)			
Fast food restaurants	0.85 (5.33)	0.14 (0.49)*	0.35 (2.01)
Other indoor restaurants	34.0 (167)	6.36 (12.3)*	12.8 (38.3)*
Supermarkets	10.3 (42.5)	2.09 (6.75)*	3.42 (8.57)*
Free markets	10.0 (47.7)	2.74 (13.7)*	4.55 (18.7)
Proximity (distance to the nearest such store in kilometers)			
Supermarket	6.26 (11.1)	4.95 (8.32)	4.47 (8.42)
Fee market	15.0 (29.2)	1.75 (3.52)*	1.25 (2.32)*
Availability (% available)			
Fast food restaurant	36 (16.8)	37 (17.1)	52 (24.4)*
Other indoor restaurant	149 (69.6)	161 (74.5)	152 (70.4)
Supermarket	143 (67.5)	107 (49.8)*	127 (60.2)
Free market	198 (94.3)	200 (93.5)	199 (92.6)
Economic food environment[‡]			
Price for most commonly eaten rice (per jin)	1.27 (0.85)	1.34 (0.22)	1.65 (0.59)*
Price for unbleached flour (per jin)	1.42 (1.65)	1.30 (0.66)	1.57 (0.38)
Price for rapeseed oil (per jin)	4.08 (1.62)	3.57 (0.87)*	5.47 (1.83)*
Price for soybean oil (per jin)	3.86 (1.33)	3.86 (2.32)	4.96 (1.80)*
Price for peanut oil (per jin)	5.51 (2.28)	5.62 (1.59)	7.24 (1.83)*
Price for cottonseed oil (per jin)	3.63 (1.54)	3.47 (1.11)	4.77 (2.78)*
Price for eggs (per jin)	3.16 (1.17)	3.32 (1.02)	4.25 (1.47)*
Price for most commonly eaten vegetable (per jin)	0.76 (0.91)	0.94 (0.93)*	1.32 (0.83)*
Price for apples (per jin)	1.38 (0.72)	1.85 (0.70)*	2.51 (0.92)*
Price for oranges (per jin)	1.14 (0.59)	1.32 (0.45)*	1.52 (0.88)*
Price for lean pork (per jin)	8.54 (1.32)	7.46 (1.40)*	11.5 (1.87)*
Price for cleaned chicken (per jin)	6.02 (2.11)	6.16 (2.84)	7.60 (2.62)*
Price for beef (per jin)	8.52 (2.10)	9.19 (2.35)*	17.5 (3.66)*
Price for mutton (per jin)	9.12 (2.74)	9.96 (3.06)*	17.9 (4.68)*
Price for fresh milk (per package-250 ml)	1.55 (0.95)	1.99 (1.90)*	2.16 (0.92)*
Price for mostly commonly eaten fish (per jin)	4.32 (2.32)	4.14 (1.25)	5.77 (2.88)*
Price for coca-cola (per can-335 ml)	2.52 (1.04)	2.84 (2.04)*	3.24 (2.76)*
Price for jianlibao (per can-335 ml)	2.47 (0.77)	2.87 (2.25)*	1.57 (0.38)*
Socio-cultural food environment[§]			
Prevalence of fast food consumption (%)	19.1 (25.5)	20.4 (27.5)	27.1 (31.7)*
Prevalence of fast food preferences (%)	44.8 (35.6)	35.0 (31. 8)*	47.7 (37.9)*
Average score for nutrition knowledge (0-12)	8.72 (1.75)	8.37 (1.65)	8.51(1.80)

[†]Based on data collected from the China Health and Nutrition Survey (CHNS) conducted in 2004, 2006 and 2009. CHNS covered 9 provinces in China.

[‡]Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2009 using consumer price index (CPI).

[§]Socio-cultural food environment was measured by aggregating individual responses from children living in each community, to show community norms for nutrition knowledge, fast food preferences, and fast food consumption.

*$p<0.05$, indicating significant difference from wave 2004; p-value obtained from zero-inflated negative binomial regressions for density, proximity, fast food prevalence and preference, from random-effect logistic models with random intercept for availability; from GEE poisson for price and nutrition knowledge.

all kinds of food outlets. Traditional and modern markets both have thrived in China over the past 2-3 decades with the increasing urbanization. Supermarkets were initially introduced to China in the 1980s. Since the 2000s, this modern way of retailing has grown rapidly.[29,30] The Chinese are selective in choosing what kind of items to

Table 2. Multi-level logistic regression to examine the impact of urbanization on the availability of food establishments in China: CHNS 2004-2009 (n=221 communities)[†‡§¶††]

	Fast food restaurant			Other indoor restaurant			Supermarket			Free market		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Model 1: urbanicity index+wave+urbanicity×wave interaction+province												
Urbanicity	3.23	2.08, 5.00	***	3.04	2.15, 4.30	***	2.34	1.77, 3.08	***	2.88	1.39, 5.97	**
Model 2: all urbancity components+wave+urbanicity×wave interaction+province												
Population density	1.37	1.10, 1.72	**	1.10	0.88, 1.37		0.97	0.82, 1.16		1.25	0.86, 1.81	
Education	1.03	0.78, 1.36		0.89	0.64, 1.25		0.85	0.65, 1.11		1.18	0.63, 2.21	
Sanitation	1.34	1.08, 1.66	**	1.06	0.90, 1.24		1.03	0.91, 1.17		0.97	0.76, 1.23	
Housing	0.94	0.72, 1.22		1.25	0.99, 1.58		1.18	0.98, 1.43		1.1	0.77, 1.59	
Transportation	0.92	0.79, 1.05		1.07	0.94, 1.20		1.00	0.90, 1.10		1.13	0.93, 1.37	
Communication	1.17	0.88, 1.54		1.29	1.01, 1.64	*	1.26	1.02, 1.55	*	1.53	1.07, 2.18	*
Health	1.31	1.12, 1.52	***	1.18	1.05, 1.33	**	1.21	1.09, 1.34	***	0.92	0.77, 1.10	
Economy	1.23	1.07, 1.43	**	1.05	0.94, 1.17		1.11	1.01, 1.22	*	1.14	0.96, 1.37	
Diversity	0.98	0.73, 1.32		1.08	0.78, 1.51		1.34	1.02, 1.77	*	1.35	0.76, 2.42	
Social service	1.01	0.91, 1.12		1.24	1.08, 1.43	**	1.02	0.93, 1.16		0.95	0.74, 1.21	

[†]Based on data from the China Health and Nutrition Survey (CHNS) in 2004, 2006 and 2009.
[‡]Based on mixed-effects logistic regression models (xtmelogit) with random intercept and unstructured covariance matrix to examine cross-sectional association between urbanicity index and food environment across waves.
[§]Model 1: urbanicity is the predictor, availability of food establishments is the outcome, adjusting for study wave, study wave×urbanicity interaction and province.
Model 2: Ten components (population density, economic activities, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, social services) of the urbanicity index are the predictors, availability of food establishments is the outcomes, adjusting for study wave, study wave×urbanicity interaction and province.
[††]For fast food restaurant and other indoor restaurant, availability was defined as having or not having inside the neighborhood; For supermarket and free market, availability was defined as having or not having within 30 minutes' bus ride.
$^{*}p<0.05$, $^{**}p<0.01$ $^{***}p<0.001$.

Table 3. Zero-inflated negative binomial regression to examine the impact of urbanization on the community-level physical and socio-cultural food environment in China: CHNS 2004-2009 (n=221 communities) [†‡§¶]

	Urbanicity		
	RR	95% CI	*p*
Physical food environment			
Density (# per 1,000 residents)			
Fast food restaurant	0.96	0.54, 1.70	
Other indoor restaurant	1.32	1.17, 1.48	***
Supermarket	1.02	0.87, 1.20	
Free market	1.02	0.92, 1.14	
Density (# per square kilometer)			
Fast food restaurant	3.69	2.59, 5.27	***
Other indoor restaurant	3.04	2.39, 3.86	***
Supermarket	2.38	1.88, 3.01	***
Free market	2.05	1.69, 2.49	***
Proximity (Distance to the nearest… in kilometers)			
Supermarket	0.59	0.50, 0.70	***
Free market	0.54	0.47, 0.62	***
Socio-cultural food environment[††]			
Prevalence of fast food consumption (%)	1.28	1.22, 1.33	***
Prevalence of fast food preferences (%)	1.09	1.06, 1.12	***
Average score for nutrition knowledge[6]	1.02	1.01, 1.03	***

[†]Based on data from the China Health and Nutrition Survey (CHNS) in 2004, 2006 and 2009;
[‡]Based on data from zero-inflated negative binomial regression (ZINB) with clustering at the community level; SE were obtained from robust variance estimation; variables used in the first step were obtained from xtmelogit in Table 2;
[§]Urbanicity as the predictor, adjusting for study wave, province and urbanicity×study wave interaction;
[¶]Questions on fast food consumption were responded by children above age six; questions on fast food preferences and nutrition knowledge were responded by children above age 12;
[††] For nutrition knowledge, GEE poisson regression was used with robust variance estimation.
$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$.

Table 4. Random-effect models to examine the impact of urbanization on community economic food environment - food prices: CHNS 1989-2009 (n=218 communities)[†‡§]

Type of food categories	Urbanicity		
	exp(β)	exp (95% CI)	*p*
Commonly consumed rice	1.01	1.01, 1.02	**
Unbleached flour	1.02	1.01, 1.03	**
Cooking oil: rapeseed oil	0.99	0.97, 1.02	
Cooking oil: soybean oil	1.00	0.98, 1.02	
Cooking oil: peanut oil	1.01	0.99, 1.03	
Eggs	1.00	0.98, 1.02	
Commonly consumed vegetables	1.08	1.04, 1.11	***
Apples	1.06	1.05, 1.08	***
Oranges	1.02	0.99, 1.04	
Pork	1.02	1.01, 1.03	***
Chicken	1.01	1.00, 1.03	
Beef	1.00	0.99, 1.02	
Mutton	1.01	1.00, 1.03	
Fresh milk	0.99	0.97, 1.01	
Mostly commonly eaten fish	1.02	1.00, 1.04	
Coca-cola (the U.S. brand soft drink)	0.99	0.98, 1.01	
Jianlibao (a Chinese brand soft drink)	0.99	0.98, 1.01	

[†]Results from the China Health and Nutrition Survey (CHNS) in 1989, 1991, 1993, 2004, 2006 and 2009.
[‡]Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2009 using consumer price index (CPI).
[¶]Random-effects models with robust SE and maximum likelihood estimation, adjusting for study wave and province; separate model was fit for each food price.
$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$.

purchase from supermarkets. A study in Shanghai found that most people preferred to buy processed food in supermarkets, while buying fresh food items (mainly vegetables) from traditional free markets.[31] Since the 1990s, the Chinese population has become more accustomed to eat away from home, while Western fast food restaurants and other restaurants are both good alternatives.[32,33]

Some components of urbanicity, such as population density, sanitation, communication, diversity, health, economy and social services were found to be significantly associated with greater availability of food places. This corresponds with the fact that fast food restaurants were

more available in places with a denser population, better sanitation, health facilities and economic conditions, all factors influencing where to locate fast food chains.

The finding that food prices (adjusted for inflation) did not change much with urbanicity may be due to the Chinese government's effort to regulate (stabilize) food prices. The government monitors food prices on a regular basis and provides recommended prices.[34] Thus, food prices surveyed remained relatively stable and did not vary much with urbanicity. Despite this fact, food prices are still an important risk factor to take into account when studying obesity in China.[34,35]

The cluster of residents living in more urbanized areas were better educated about nutrition, were more favorable to fast food and ate in fast food restaurants more frequently. There appears to be a mismatch between knowledge, attitudes and actual behaviors. Unlike in the developed countries, many Western fast food chains market their products as well balanced, sanitary and healthy. People also have more trust in fast food restaurants due to food safety concerns in other food vendors.[34,36] A cross-country study investigated 795 young consumers from China and U.S. and found that the Chinese participants were more favorable towards KFC and were more likely to eat there than their American counterparts.[37] Moreover, people, especially young people living in megacities, cared more about "fast" rather than "food" due to the fast modern life pace.[38,39] Finally, fast food was more accessible and acceptable in more urbanized areas, and this partially leads to the higher prevalence of childhood obesity in urban versus rural areas.

Westernization, as shown by changing lifestyles, may serve to be a confounder between food environment and urbanization; however, while human behaviors such as Westernization shape and change the environment, the environment also changes human behaviors, as suggested by Bandura's Social Cognitive Theory.[40]

This study has several key strengths. First, its longitudinal design made it possible to examine whether the association between urbanization and food environments differs by study wave. Second, this is the first study to look into the impact of urbanization (and its different dimensions) on different dimensions of food environment. Third, this study in China, the largest developing country with a fast growing economy, provides useful insights for other developing countries facing the emerging threat of obesity and NCDs.

The study also suffers from a few limitations. First, data on local food environments were reported by community heads, making their accuracy of concern. Second, there was no information reported on prices of prepared foods (e.g., fast food, prepared food sold at other food vendors) except a few reported in the 2009 wave, while nutrients in raw foods may be quite different after they are processed. Next, the sample mainly came from the more affluent, eastern provinces, and thus may not well represent the poorer, western provinces.

In conclusion, urbanicity was positively associated with access to all kinds of food outlets, better nutrition knowledge, and more prevalent fast food preferences and consumption. Its association with food prices was not obvious for many, but showed a positive relationship for some foods like the prices for rice, unbleached flour, vegetables, apples and lean pork.

The rapid urbanization in China has brought in both opportunities and threats to public health. The key is to encourage the beneficial components of urbanization, while reduce adverse components. More studies are needed to understand and test such components and interventions, and the mechanisms through which they impact population health. Though food prices did not show a clear link with urbanization, the Chinese government still needs to be cautious about the potential effect of economic growth and price change on food purchasing and consumption, as evidenced in the rising consumption of edible oil and fat. The mismatch between norms on nutrition knowledge and fast food consumption urges relevant stakeholders such as policy makers, public health professionals and researchers to promote healthful urbanization and eating.

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AUTHOR DISCLOSURES

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Appendix A. The ten dimensions of the urbancity scale[†]

The description of the dimensions was from the cited reference:
1. Population density (0-10): total population of the community divided by community size, from official records;
2. Economic activity (0-10): typical daily wage for an ordinary male worker (reported by community officials), and % of the population engaged in non-agricultural work;
3. Transportation infrastructure (0-10): most common types of road, mean distance to bus stop, and to train stop;
4. Sanitation (0-10): proportion of households with treated water, and prevalence of households without excreta present outside the home;
5. Communications (0-10): availability of a cinema, newspaper, postal service, telephone service, and % of households with a computer, % of households with a television, and % of households with a cell phone;
6. Housing (0-10): average number of days a week that electricity is available to the community, % of community with indoor tap water, % of community with flush toilets, and % of community that cooks with gas;
7. Education (0-10): average education level among adults >21 years old;
8. Diversity (0-10): variation in community education level, and variation in community income level;
9. Health infrastructure (0-10): number and type of health facilities in or nearby (≤12 km) the community, and number of pharmacies in the community;
10. Social services (0-10): provision of preschool for children under 3, availability of commercial medical insurance, free medical insurance, and/or insurance for women and children.

[†]Reference: Jones-Smith JC, Popkin BM. Understanding community context and adult health changes in China: development of an urbanicity scale. Soc Sci Med. 2010;71:1436-46.