The rising overweight epidemic in China: An age-period-cohort analysis, 1989-2009

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Abstract

Using eight successive waves of the China Health and Nutrition Survey dataset, this paper estimates hierarchical age-period-cohort models (HAPC) to investigate the prevalence of overweight individuals in the population ages 2 to 60. We find that the prevalence of overweight declines from early childhood to adolescence and then increases through the adult ages until the early 50s after which the age trajectory again declines. The period effects are very strong with a virtually monotonic increase in overweight from 1989 to 2009. Furthermore, cohorts born in the early 1950s before China's great famine (from the spring of 1959 to the end of 1961) are less likely to be overweight, whereas cohorts born in the 15 years after the great famine tend to be overweight. Since 1975, the cohort effects have decreased, with some fluctuations. Finally, we find evidence of sex, regional, and income disparities in the age, period and cohort effects.

Extended Abstract

Introduction

Previous studies have widely reported that the prevalence rates of overweight individuals in China have been rising steadily in the most recent two decades (Cui et al. 2010; Luo and Hu 2002; Wang, Ge and Popkin 2000). However, the question as to whether these increases in the prevalence rates can be attributed to the aging of the Chinese population, a secular and monotonic increase in overweight rates across time, or to the replacement of older cohorts with heavier cohorts born in more recent years. In this study, we estimate age, period, and cohort effects on the overweight epidemic in China by hierarchical age-period-cohort analyses (HAPC).

Measures

For adults aged 18 and above, their overweight status is determined by the widely used adult BMI cut-point of 25 kg/m^2. For children and adolescents aged below 18, the age- and sex-specific BMI cut-points proposed by the International Obesity Task Force (IOTF) are used to screen childhood overweight (Cole et al. 2000). The IOTF standards are based on children and adolescents from Brazil, Great Britain, Hong Kong, Netherlands, Singapore, and the United States, which restricted their fitted BMI curves to pass through the adult cut-point of 25 kg/m^2 at age 18. Because the IOTF provides cut-points for six-month intervals for children aged 2 and older, we used a polynomial method to estimate continuous age- and sex-specific cut-points for individuals aged below 18. Results from this polynomial interpolation yielded BMI cut-points for a person’s exact age. Based on prior research (Johnson et al. 2006; Luo and Hu 2002; Wang, Ge and Popkin 2000), the age, period and cohort effects on overweight rates for certain socio-demographic groups in China are also examined. These socio-demographic covariates include: sex (male *versus* female), residency (rural *versus* urban residents), and income (whether an individual came from a household with per capita income below or above the median per capita household income of all households interviewed in a certain wave).

Data

Data from the China Health and Nutrition Survey (CHNS), an ongoing open-cohort survey that provides information on the nutrition and health status of the Chinese population, are analyzed. The first wave of the CHNS was collected in 1989, followed by seven cross-sectional waves collected in 1991, 1993, 1997, 2000, 2004, 2006 and 2009. The survey covers nine provinces (*Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning,* and *Shandong*) that vary substantially in geographical location, economic development, social resources, and health status. Individuals aged 2 to 60 at the eight waves of CHNS are included in the analyses.

Method

Hierarchical age-period-cohort models are employed to study the overweight epidemic in China from 1989 to 2009. The level-1 (within-unit) fixed effects part of the HAPC model can be expressed as follows:

$$\log\frac{p_{ijk}^{overweight}}{1-p_{ijk}^{overweight}} = a_{ijk} + \beta_{1jk}age + \beta_{2jk}age^2 + \beta_{3jk}age^3 + e_{ijk} \quad (1)$$

where $p_{ijk}^{overweight}$ represents the probability of being overweight for the ith individual in the jth period of observation and the kth birth cohort. Given the fact that the age interval investigated in the current study is relatively long (age 2-60), both the square and cubic terms of age are also included in the model to estimate possible curvilinear effects of age on the probability of being overweight.

The level-2 (between-unit) random effects part of the HAPC model for estimation of period and cohort effects is:

$$a_{jk} = \pi_0 + t_{0j} + c_{0k} \quad (2)$$

where π_0 is the mean averaged over all periods and cohorts when all level-1 variables (age and its square and cubic terms) are zero; the t_{0j} s are residual random effects of period j averaged over all birth cohorts, which are assumed to be normally distributed with variance τ_{t0}; and the c_{0k} s are residual random effects of cohort k averaged over all periods of observation, which are assumed to be normally distributed with variance τ_{c0} (Raudenbush and Bryk 2002; Yang and Land 2006). A χ^2 test is conducted to compare whether a model with random period and cohort effects significantly fits data better than a corresponding reduced model without random effects. The HAPC models are estimated by SAS PROC GLIMMIX (Littell et al. 2006). Due to moderate sample size, birth cohorts are classified by every five years. Moreover, individuals born before 1935 are grouped into the 1930 birth cohort and individuals born at the year 2000 and after are grouped into the 2000 birth cohort.

Results

- Age effects: The prevalence of overweight declines from early childhood to adolescence and then increases over the adult ages until the early 50's. The age trajectory in overweight declines again afterwards.
- Period effects: We find a virtually monotonic increase in overweight prevalence from 1989 to 2009 – the period effects are very strong.
- Cohorts effects: Cohorts born in the early 1950s before China's great famine (from the spring of 1959 to the end of 1961) are less likely to be overweight, whereas cohorts born in the 15 years after the great famine tend to be overweight. Since 1975, the cohort effects have decreased, with some fluctuations. which mirrors the influence of multifaceted social changes (e.g., large-scale rural migration, urban transformation, and economic growth) on the overweight epidemic.
- Covariates: We find statistically significant sex, regional and income disparities in the age, period and cohort effects on the overweight prevalence rates.

Table 1 Hierarchical age-period-cohort analyses of overweight for Chinese population and socio-demographic groups, CHNS 1989-2009

	Overall population	Male	Female	Urban Residents	Rural Residents	High-income families	Low-income families
Fixed effects							
Intercept	-0.9575***	-1.0020**	-0.9068***	-0.8848**	-0.9637***	-1.0306***	-0.8207**
Age [a]	-2.2880***	-2.3728***	-2.3423***	-2.0535***	-2.4359***	-1.9516***	-2.6614***
Age^2	0.8912***	0.9434***	0.8920***	0.7964***	0.9457***	0.7842***	0.9940***
Age^3	-0.0861***	-0.0933***	-0.0838***	-0.0756***	-0.0920***	-0.0765***	-0.0946***
Random effects							
Period effects							
1989	-0.3170**	-0.4912**	-0.1408	-0.2934*	-0.3248*	-0.3538**	-0.2688
1991	-0.4358***	-0.5812***	-0.2864***	-0.3672***	-0.4599***	-0.3470**	-0.5423***
1993	-0.3050*	-0.3704*	-0.2223**	-0.2401*	-0.3240*	-0.3098**	-0.2828*
1997	-0.0762	-0.0998	-0.0424	0.0044	-0.1306	-0.0348	-0.1320
2000	0.1875	0.2365	0.1429	0.2287*	0.1615	0.1860	0.1858
2004	0.2737*	0.3352*	0.2016*	0.2550*	0.2793*	0.2699*	0.2755*
2006	0.2886*	0.4333**	0.1364	0.1832	0.3402**	0.2571*	0.3322*
2009	0.3843**	0.5376**	0.2110*	0.2293*	0.4583***	0.3323**	0.4325**
Cohort effects							
1930	0.1584	0.1694	0.0586	0.1792	0.0337	0.1688	0.0504
1935	-0.0451	-0.0025	-0.1515	0.0847	-0.1474	-0.0061	-0.1243
1940	-0.1503*	-0.3580**	-0.0435	-0.1610	-0.1076	-0.1375	-0.1498
1945	-0.1105	-0.3045**	0.0041	0.0440	-0.1913*	-0.0738	-0.1548
1950	-0.1937***	-0.2853**	-0.1421*	-0.2511***	-0.1380*	-0.1547**	-0.1955*
1955	0.0306	-0.1892*	0.2043***	0.0424	0.0333	0.0313	0.0556
1960	0.0859	0.0708	0.1148	0.0041	0.1415*	0.0356	0.1551
1965	0.1648**	0.1981*	0.1751**	-0.0265	0.2725***	0.0585	0.3026***
1970	0.1359*	0.1929*	0.1334	0.0472	0.1904**	0.0228	0.3188***
1975	0.0917	0.2699**	-0.0176	0.0000	0.1512	-0.0060	0.2292*
1980	-0.0114	0.2443*	-0.2000*	-0.1003	0.0448	-0.0340	0.0128
1985	0.0913	0.2493*	-0.0219	-0.0312	0.1516	0.0110	0.1456
1990	-0.1922*	-0.0831	-0.2234*	-0.0567	-0.2364*	-0.0904	-0.2995*
1995	0.1592	0.2270	0.1147	0.2786*	0.0766	0.2512**	-0.0118
2000+	-0.2146*	-0.3990*	-0.0052	-0.0532	-0.2747*	-0.0767	-0.3342*
χ^{2} [b]	942.74***	190.08***	787.03***	800.80***	249.28***	401.74***	488.95***

Note: [a] the coefficients and standard errors for age, age^2 and age^3 have been multiplied by 10, 100 and 1000, respectively.

[b] The likelihood ratio χ^2 test compares the full model with random effects for period and cohort with a reduced model omitting random effects.

*p<.05; **p<.01;***p<.001 (two-tailed tests)

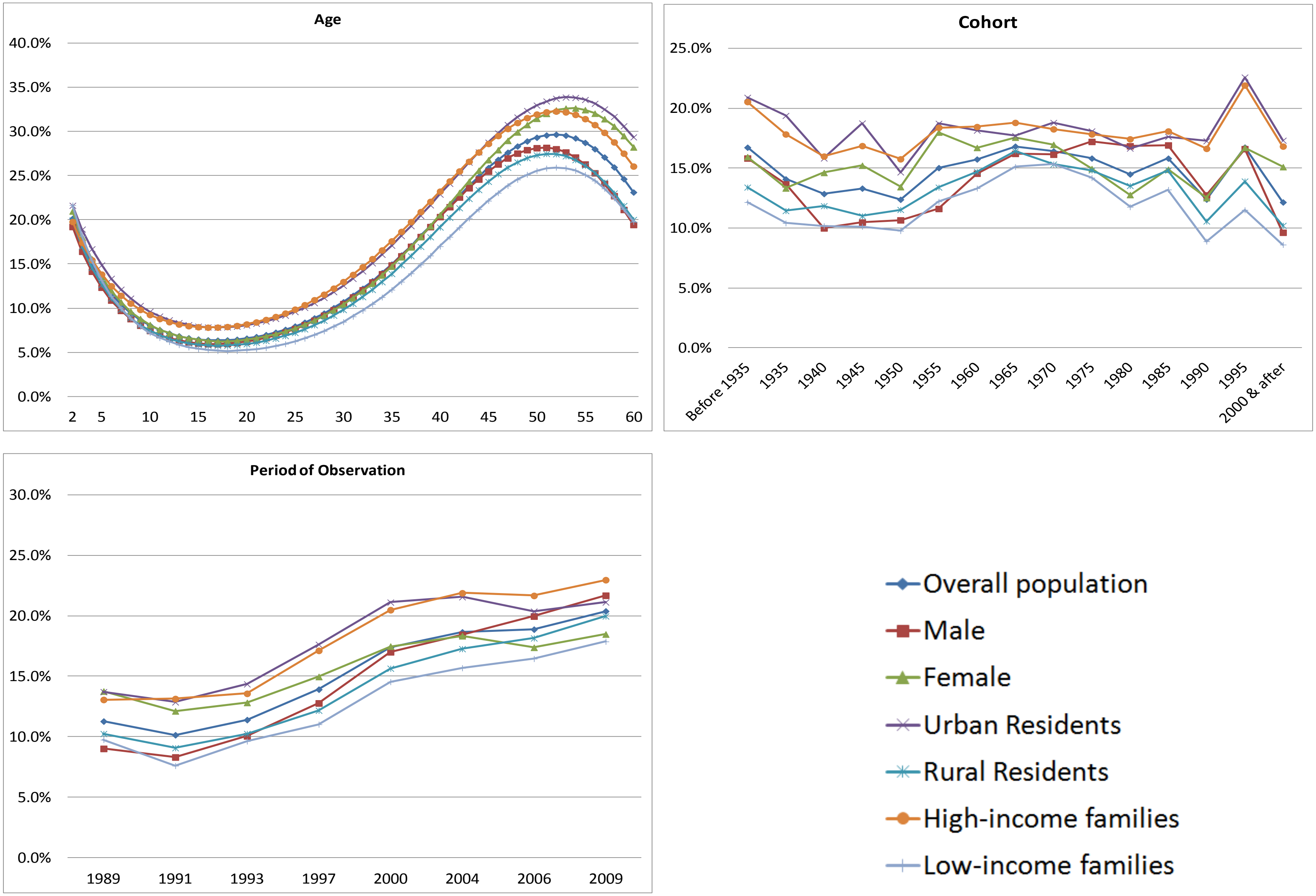

Figure 1 Predicted probabilities of overweight for Chinese population and socio-demographic groups using hierarchical age-period-cohort models, CHNS 1989-1991

References

Cole, Tim J., Mary C Bellizzi, Katherine M Flegal and William H Dietz. 2000. "Establishing a Standard Definition for Child Overweight and Obesity Worldwide: International Survey." *British Medical Journal* 320(1240): 1-6

Cui, Z., R. Huxley, Y. Wu and M.J. Dibley. 2010. "Temporal Trends in Overweight and Obesity of Children and Adolescents from Nine Provinces in China from 1991–2006." *International Journal of Pediatric Obesity* 5(5): 365-74

Johnson, C. Anderson, Bin Xie, Chunhong Liu, Kim D. Reynolds, Chih-Ping Chou, Carol Koprowski, Peggy Gallaher, Donna Spruitj-Metz, Qian Guo, Ping Sun, Jie Gong and Paula Palmer. 2006. "Socio-Demographic and Cultural Comparison of Overweight and Obesity Risk and Prevalence in Adolescents in Southern California and Wuhan, China." *Journal of adolescent health* 39(6): 925.e1-8

Littell, Ramon C, George A Milliken, Walter W Stroup, Russell D Wolfinger and Oliver Schabenberger. 2006. *Sas for Mixed Models*. SAS Institute Inc.

Luo, Juhua and Frank B Hu. 2002. "Time Trends of Obesity in Pre-School Children in China from 1989 to 1997." *International journal of obesity* 26(4): 553-58

Raudenbush, Stephen W. and Anthony S. Bryk. 2002. *Hierarchical Linear Models: Applications and Data Analysis Methods*. Sage Pubns.

Wang, Y., K. Ge and B.M. Popkin. 2000. "Tracking of Body Mass Index from Childhood to Adolescence: A 6-Y Follow-up Study in China." *The American Journal of Clinical Nutrition* 72(4): 1018-24

Yang, Yang and Kenneth C. Land. 2006. "A Mixed Models Approach to the Age-Period-Cohort Analysis of Repeated Cross-Section Surveys, with an Application to Data on Trends in Verbal Test Scores." *Sociological methodology* 36(1): 75-97