ELSEVIER

Social Science & Medicine 59 (2004) 1505–1515

SOCIAL SCIENCE & MEDICINE

www.elsevier.com/locate/socscimed

Rapid income growth adversely affects diet quality in China—particularly for the poor!

Shufa Du[a,b], Tom A. Mroz[a], Fengying Zhai[b], Barry M. Popkin[a,*]

[a] *Department of Nutrition and Carolina Population Center, University of North Carolina at Chapel Hill, University Square, CB #8120, 123 West Franklin Street, Chapel Hill, NC 27516, USA*

[b] *Institute of Nutrition and Food Safety, Chinese Centers for Disease Control and Prevention, 29 Nanwei Road, Beijing 100050, China*

Abstract

To study the impact of income change—specifically rapid income growth—on diet behavior over time and by socioeconomic level, we used data from a prospective study of China begun in 1989 (followed up in 1991, 1993 and 1997). The subpopulation used in this study included 5783 subjects aged 20–45 years old from 3129 households. Dietary intakes were measured using a combination of the weighing method and three consecutive 24-h recalls. Detailed income and price data were collected, and predicted household per capita income was used in multivariate longitudinal random-effects models that described the consumption of several food groups and nutrients. Income elasticity was used to measure the changes for the effects of income over time on (a) the probability of consuming any food and (b) the quantity of food consumed. The structure of the Chinese diet is shifting away from high-carbohydrate foods toward high-fat, high-energy density foods. The variation in the income effects that we uncovered indicated that important changes in income effects took place between 1989 and 1997, with the changes varying considerably by socioeconomic status. These shifts in income effects indicate that increased income might have affected diets and body composition in a detrimental manner to health, with those in low-income groups having the largest increase in detrimental effects due to increased income. Extrapolating from our estimates, higher income levels in the future could lead to the reversal of the health improvements achieved in the last two decades, if diet-related noncommunicable diseases cannot be controlled.

Keywords: Obesity; Income; Mortality; Dietary behavior; Random-effects; China

Introduction

Throughout the developing world, there has been a marked transition in dietary and physical activity and overall body composition patterns in the past half century. Particularly, in the past decade, we have seen a rapid shift toward a pattern of nutrition more linked with noncommunicable diseases than undernutrition in developing countries (Popkin, 2002). Economic growth has succeeded in significantly reducing poverty and accelerating the nutrition transition. The number of absolutely poor people (living on less than $1 a day) in developing countries fell from 1.3 billion to 1.2 billion and the proportion of people living in extreme poverty (daily expenditures less than the cost of a basic food basket) fell from 29% to 23% over the past decade (World Bank, 2002). The annual growth rate of the gross domestic products (GDP), in China, for example, was 8% in the past two decades—the highest rate in recent world history. As a result, the proportion of the absolutely poor population in China decreased sharply from 80% in 1978 to less than 12% in 1998; the proportion of the extremely poor decreased from 20% to 6% during the same period (State Statistical Bureau, 2002).

Following rapid economic and social change, the pace of the nutrition transition accelerated in developing countries. The prevalence of obesity and diet-related

*Corresponding author. Tel.: +1-919-966-1732; fax: +1-919-966-9159.

E-mail address: popkin@unc.edu (B.M. Popkin).

0277-9536/$ - see front matter
doi:10.1016/j.socscimed.2004.01.021

noncommunicable diseases (DR-NCD) increased far more quickly in developing countries than in Western countries (Popkin, Paeratakul, Zhai, & Ge, 1995a). From the perspective of development, the effects of increased income have generally been viewed as beneficial, since higher income is associated with better quality diets, better health care, better child growth, and lower morbidity and mortality from infectious diseases. On the other hand, as income increases, dietary changes typically include higher energy and fat intakes, increased consumption of animal foods and processed foods—which may not be healthful. Many researchers who explored the effects of socioeconomic status (SES) on nutrition focused on measures of undernutrition, undesirable pregnancy outcomes, or infant mortality. Although other researchers who documented income–health relationships focused either on estimating overall income–nutrient intakes or on child health-related behaviors—such as infant feeding and growth (Sharkey et al., 2002; Giskes, Turrell, Patterson, & Newman, 2002), more attention has been paid to the effects of poverty (Nelson, 2000; Doran and Evers, 1997; Block, Norris, Mandel, & DiSogra, 1995). However, the issue of potential detrimental effects of income on diet has rarely been explored. Few researchers focused on (a) outcomes such as obesity or cardiovascular diseases (CVD), (b) risk factors for DR-NCD, (c) how income change impacts decision-making for food consumption or (d) how food structure shifts as income increases (Guo, Mroz, Popkin, & Zhai, 2000; Popkin, Paeratakul, Zhai, & Ge, 1995b). This paper will present such issues and their implications on public health.

Data and methods

Survey design

Analysis was based on data of the China Health and Nutrition Survey, an ongoing longitudinal project with 5783 subjects aged 20–45 years old from 3129 households in 1989 and followed up in 1991, 1993, and 1997. A multistage, random cluster process was used to draw the sample in eight provinces in China. Counties in the eight provinces were stratified by income (low-, middle-, and high-) and a weighted sampling scheme was used to randomly select four counties in each province. In addition, the provincial capital and a lower income city were selected. Villages, townships (within the counties), and urban and suburban neighborhoods (within the cities) were selected randomly. The survey framework contained 190 primary sampling units consisting of 32 urban neighborhoods, 30 suburban neighborhoods, 32 townships, and 96 villages.

Diet data

We collected diet data at both the household and individual levels. Household food consumption was determined by a detailed examination of changes in inventory from the beginning to the end of each day—for three consecutive days, in combination with a weighing technique. The three consecutive days, during which detailed household food consumption data were collected, were randomly allocated from Monday to Sunday. Chinese food scales with a maximum limit of 15 kilograms (kg) and a minimum of 20 grams (g) were used to weigh the food. All purchases, home production, and processed snack foods were weighed and recorded. Preparation waste (e.g., spoiled rice, discarded cooked meals fed to pets or animals) was estimated when weighing was not possible. At the end of the survey, all remaining foods were again weighed and recorded.

Dietary intake at the individual level was surveyed by 24-h recalls for the same three consecutive days by asking individuals to report all food consumed each day away from home and at-home, on a 24-h recall basis. We linked household food consumption with individual consumption based on the percent of individual consumption of any food as a proportion of that the household used. Also, we adjusted individual reported consumption by the amount weighed at the household level—if there was a large difference of consumption between the household and individual levels.

Income data

Detailed demographic, economic, time-use, labor-force participation, asset ownership, and expenditure data were obtained. Income was approximated from the survey in three ways: (a) through responses to direct questions about income, (b) through the summation of net receipts from all reported activities, and (c) through responses to questions about expenditures. Full income from market and nonmarket activities was imputed. In analysis, income and price variables were deflated (by the consumer price index) to Chinese currency (measured in 1980 yuan). To reduce the potential biases due to measurement errors, we log-transformed the measured household per capita income and predicted it with a set of community and household variables. We then used the predicted income and its square as income measures in the analysis of food consumption. Separate income regressions were conducted for each of the four survey years.

Price data

We had three sources of price data: (a) state store price, (b) authority price records, and (c) free market price (including local markets and super markets).

Individual-owned supermarkets and free markets have gradually replaced state stores since 1989 and people usually buy food and commodities in the free markets. The free market price became the most informative in terms of affecting consumption decisions; therefore, only free market prices were used as independent variables in all models.

Analysis methods

We used a two-step procedure to estimate the effects of income on food consumption because determinants of the decision to consume any given food often differed from the determinants of how much to consume. First, we examined the yes–no consumption decision for a given food and second, the quantity consumed—for those who consumed that food. This two-step procedure can provide more accurate estimations (Haines, Guilkey, & Popkin, 1988). The consumption measures, probability and quantity, were separately regressed on predicted log-household per capita income.

Income elasticity was used to measure the effects of income on food consumption. Income elasticity measures the relationship between a change in quantity consumed and a change in income (i.e., Income Elasticity = Percent change in consumption/Percent change in income). Income elasticity defines three types of food: inferior, normal and superior or luxury foods. Inferior foods have a negative elasticity which means that food consumption decreases as income increases. Superior or luxury foods have a positive elasticity. Normal food has an income elasticity near zero, which means the consumption is unresponsive to a change in income.

There are two kinds of effects in cross-sectional time-series data: (a) the cross-sectional effects reflected in the differences between subjects and (b) the time-series, or within-subject effects reflected in the changes over time for the subjects. Only random-effects models can estimate both effects simultaneously (Stata Corp., 2001). We built (a) random-effects probit models to predict the probability of consuming any given food group and (b) time-series random-effects regression models to predict the quantity of food consumption. When we predicted the effects of income on food consumption, we controlled for a set of time-varying variables (e.g., key food prices, kerosene and gasoline prices, family size, age, education, etc.) and time-invariant variables (e.g., urban residence, region of residence, etc.). We used a bootstrap sampling and estimation procedure to estimate the statistical precision measures for the estimated income elasticity as functions of income levels (e.g., point-wise standard errors and 95% confidence intervals). The advantage of the bootstrap strategy is described elsewhere (Efron and Tibshirani, 1993; Davison and Hinkley, 1997). We used SAS version 8.2 software to manage and clean the datasets and Stata version SE 7 software to implement all analyses.

Results

Before examining the regression analyses relating changes in diet patterns to income, we first examined a few basic trends in Chinese diets over time with a special emphasis on how these trends varied across broadly defined income groups. The overall trends we uncovered indicated that there were substantive shifts in the diet towards more high-fat, more animal products, and lower consumption of traditional foods. After establishing these basic trends, our regression analyses highlighted the importance and significance of income to explain these changing patterns.

Dietary structure is changing

Total energy intake is decreasing. The Chinese government initiated a series of food policies to abolish government food procurement and rationing system beginning in 1988. As a result, the food supply improved quickly and diverse foods became available. The first panel of Table 1 presents average energy intakes by income levels in 1989, 1991, 1993, and 1997. The first change in diet patterns can easily be seen in total energy intakes. Overall energy consumption decreased substantially from 2651.2 kcal per person per day in 1989 to 2544.5 kcal in 1997. The decreasing trend is different across income groups. Total energy intakes were always lower in the high-income tertile, but declines were larger for the low- and middle-income tertiles. There was a 227.5 kcal decrease from 1989 to 1997 in the low-income tertile, but only an 86 kcal decrease in the middle-income

Table 1
Energy intake and consumption of high-fat diet, adults aged 20–45 yr, 1989–1997, China

Income tertile	1989	1991	1993	1997
Energy Intake (kcal per day)				
Low income	2822.1	2808.6	2703.7	2594.6
Mid income	2612.7	2713.9	2601.1	2526.7
High income	2519.9	2600.7	2486.6	2509.6
Average	2651.2	2707.2	2596.4	2544.5
High-fat diet consumption (% of sample that consumed a diet with $\geqslant$30% energy from fat)				
Low income	7.4	7.9	10.5	17.5
Mid income	14.1	18.1	22.1	36.9
High income	20.1	32.8	43	59.8
Average	13.8	19.6	25.2	37.5

tertile. Energy intake was stable in the high-income tertile, decreasing only 10.3 kcal.

Consumption of a high-fat diet is increasing. The second panel of Table 1 presents changes in those consuming a high-fat diet over time. We defined a high-fat diet in this study as one with energy from fat higher than, or equal to, 30% of total energy (WHO, 1990, 2002). The average incidence of high-fat diets rose from 13.8% to 37.5% in the eight-year span. The average incidence in the high-income tertile of high-fat diets in 1997 was almost three times higher than that in 1989 (59.8% vs. 20.1%); it more than double in the low- and middle-income tertiles. Combined with the changes in energy levels, the diets have been shifting from higher energy into higher fat diets.

Consumption of traditional foods is decreasing. Chinese traditional foods were characterized by many staple foods (i.e., rice, wheat and wheat products), as available, with a small amount of vegetables and a few animal foods. Table 2 contains the average consumption for flour, rice, animal products, and edible oil by income tertiles across time. As income improved, although the proportion of the population who consumed staple foods increased, the consumption of these staples decreased from 1989 to 1997, with the largest declines taking place for those in the low-income tertile. For example, average rice consumption per consumer decreased 110.1 g per day (469.9 vs. 359.8 g) in the low-income tertile, while only decreasing by 38 g per day (329.7 vs. 291.7 g) in the high-income tertile.

Consumption of animal foods is increasing. Animal foods were luxury foods in China and only a few rich people could regularly consume them before 1988, but more people can afford them now. The proportion of people who ate animal foods increased from 91.9% in 1989 to 97.1% in 1997 in the high-income tertile and from 63.8% to 72.7% in the low-income tertile. The average per capita consumption of animal products increased by about 30% for all three income tertiles. The absolute increases were largest for the high-income tertile; their intake level and the increase were almost twice that of those in the lower income group (Table 2). The main source of animal foods was pork and pork products—about 70% of the total animal foods consumed before the 1980s. Pork consumption decreased significantly in the past two decades, while shares of poultry, beef, and mutton increased significantly (results not shown in this paper, see Du, Lu, Zhai, & Popkin, 2002).

Consumption of edible oil is increasing. Plant oil and lard were included as edible oil in this study. Since the price of edible oil was cheaper than before, it became

Table 2
Consumption of some food groups, adults aged 20–45 yr, 1989–1997, China

Income tertile	Mean intake per capita ($g\,d^{-1}$)				Proportion of sample consuming (%)				Mean intake per consumer ($g\,d^{-1}$)			
	1989	1991	1993	1997	1989	1991	1993	1997	1989	1991	1993	1997
Consumption of flour and flour products												
Low income	177.4	215.5	249.5	218.5	52.3	62.2	71	72.4	339.4	346.5	351.4	301.7
Mid income	184.2	174.3	166.2	152	69.7	69.2	70.2	72.6	264.4	251.7	236.8	209.4
High income	159.4	156.6	124.5	129.6	75.7	78.2	73.1	75.7	210.5	200.1	170.3	171.3
Average	173.7	182.1	180.1	166.7	65.9	69.9	71.4	73.6	263.6	260.6	252.1	226.6
Consumption of rice and rice products												
Low income	345.3	331.6	298.1	289.4	73.5	73.5	73.2	80.5	469.9	451.2	407.4	359.8
Mid income	315.5	332.8	324.1	306.7	82.2	86.8	85.3	90.7	383.8	383.5	379.7	338.2
High income	299.8	299.1	297.5	273.1	90.9	91.6	93.2	93.6	329.7	326.5	319.2	291.7
Average	320.2	321.1	306.6	289.8	82.2	84	83.9	88.3	389.5	382.5	365.4	328.3
Consumption of animal source foods (pork, poultry, beef, mutton, fish, eggs, dairy)												
Low income	61.4	67.6	71.2	82.7	63.8	71.7	66.8	72.7	96.3	94.2	106.6	113.8
Mid income	107.2	120.2	118.7	137.5	82.8	85.6	83.7	88.8	129.5	140.3	142	154.9
High income	145.1	164	187.4	209.1	91.9	93.1	97.3	97.1	157.8	176.2	192.5	215.2
Average	104.6	117.3	125.8	143.1	79.5	83.5	82.6	86.2	131.5	140.5	152.3	166
Consumption of edible oils												
Low income	20.2	33.8	34.6	43.8	81.3	99.2	99.9	100	24.8	34.1	34.6	43.8
Mid income	24.4	42.1	40.1	43.9	85.5	99.8	99.8	100	28.5	42.2	40.2	43.9
High income	25.2	49	47.2	51.6	85.1	99.9	99.8	100	29.6	49	47.4	51.6
Average	23.2	41.6	40.7	46.4	84	99.6	99.8	100	27.7	41.8	40.7	46.4

more affordable, even for low-income people. The proportion of people who consumed edible oil increased from 84% in 1989 to 100% in 1997. The average quantity consumed nearly doubled for all income tertiles, with the average amount per consumer increasing by two-thirds on average across income groups. Although edible oil consumption was lower in the low-income tertile than in the high-income tertile (43.8 vs. 51.6 g per day), it increased by 76% in the low-income tertile—much faster than in the high-income tertile (40%).

These aggregate statistics point out some of the most important changes in Chinese diets during the 1990s. While the incidence of high-carbohydrate staple food consumption increased, this was met with a substantial decline in the amount consumed per consumer. Most of the largest declines in the overall consumption of these staples occurred in the lowest income groups. As more people consumed these foods, the amount being consumed declined. A different situation emerged for the relatively high-fat animal foods and edible oils. While there were similar increases in the incidence of consumption of these high-fat foods, the average quantities consumed clearly increased for all income groups. Apparently diets became more varied with everyone consuming more types of foods, but this change occurred as the source of calories shifted from high-carbohydrate foods to high-fat foods.

Overweight and obesity are increasing

Table 3 displays the prevalence of overweight and obesity (body mass index [BMI] $\geqslant 25$) by income groups. We combined overweight (BMI $\geqslant 25$) and obesity (BMI $\geqslant 30$) in this study because experts from WHO (Asia–Pacific Region) recommended that lower BMI cutoff points for overweight and obesity of 23 and 25 $kg\,m^{-2}$, respectively, should be used in Asia (Inoue and Zimmet, 2000). The prevalence of overweight and obesity was positively associated with income; it was about twofold higher in the high-income tertile than in the low-income tertile (19.6% vs. 10.9%). The average prevalence increased by 50% in the eight-year period, but in the low-income tertile it increased over 70%. The increase trends paralleled the shifts of dietary structure just documented.

Table 3
Combined prevalence of overweight and obesity (BMI $\geqslant 25$), adults 20–45 yr, 1989–1997, China (%)

Income tertile	1989	1991	1993	1997
Low income	6.3	6.6	9.5	10.9
Mid income	9.1	11.7	10	14.7
High income	10.7	13.6	13.5	19.6
Average	10.3	10.6	10.9	15.4

Note: Combined overweight and obesity prevalence based on WHO (Asia–Pacific Region) recommendation.

Mortality of diet-related noncommunicable diseases is increasing

Following the nutrition transition, the pattern for death causes is shifting away from infectious diseases toward DR-NCD. The specific mortality of hypertension increased from 8.2 to 13.5 per 100,000 between 1984 and 1999, CVD from 153.2 to 193.0, diabetes from 5.1 to 15.4, and cancer from 116.2 to 140.5, respectively. This shift is noteworthy, as it seems to be concurrent with the increase in DR-NCD related to the circulatory system and cancer. Furthermore, the increase in the total mortality since the 1990s should not be overlooked. There was no clear increase in the total mortality before 1990, but an increase of 34.7 per 100,000 thereafter.

Impacts of income change on food consumption vary over time and across income groups

We use random effects models to demonstrate that variations in income are significant determinants of the components of the basic diet trends just discussed. We examine how the propensity to consume any of the food, and how the quantity consumed (given some consumption), varies with income. In all regressions we used the same set of explanatory variables, which includes a set of food prices, age, gender, residence, and urbanization index. Given the nonlinear nature of the income effects we uncovered, the actual parameter estimates are not very informative; instead we report the implied impacts of income on the consumption and information about statistical significance of these effects in graphical form. Specifically, we present graphs describing how the income elasticity of the consumption varies across income levels in both 1989 and 1997 for each of these consumption outcomes. We also present graphs displaying the eight-year change in the income elasticity by income level. All graphs contain point-wise 95% confidence intervals (bands) for the estimated income elasticity, or for their changes over time and follow the same format for displaying the elasticity by income level and their changes over time.

Flour and rice products have become inferior goods. The first graph in Fig. 1a displays the income elasticity for the probability of consuming any flour products in 1989. Our model specifications incorporate nonlinear income effects, resulting in elasticity that can vary by income level. The bands about the income elasticity define point-wise 95% confidence intervals for the elasticity estimates. The second graph in Fig. 1a presents similar information for the income elasticity in 1997.

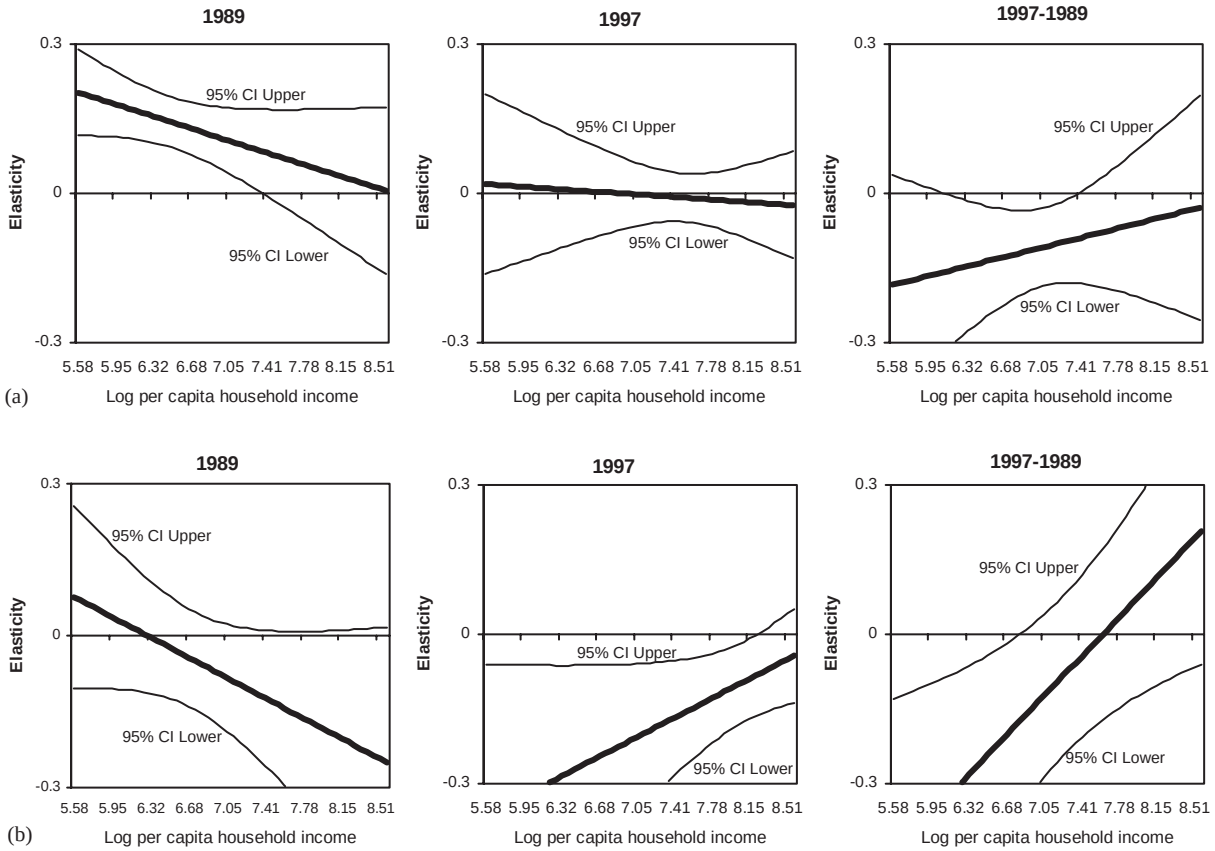

Fig. 1. (a) Income elasticity for the probability of flour food consumption. (b) Income elasticity for the quantity of flour food consumption.

The third graph in the figure presents the change in the income elasticity at each income level.

The probability of consuming any flour products was quite responsive to income in 1989, with the incidence for the poor being higher than that for the nonpoor for the incidence of consuming flour products. By 1997, however, this elasticity declined to almost zero at all income levels, implying that decisions about whether to consume any flour products were nearly independent of ones income. From the third graph in Fig. 1a we see that these changes in the income elasticity were statistically significant over much of the relevant income range. One interpretation of this change over time is that income in 1997 was high enough for almost everyone that it was not a limiting factor in one's decision to consume any flour products.

Fig. 1b presents the income elasticity and its changes for the amount of flour products consumed (among those who consumed some flour). The income effects are much different than for the incidence of flour consumption. The amount of flour consumed in 1989 (first graph) was only weakly related to one's income level, with the point estimates suggesting that flour products were inferior goods over most of the relevant income range. In 1997 (second graph) the quantity of flour products consumed indicated that they were clearly an inferior good with a statistically significant negative elasticity over almost the entire income range. The change in the income elasticity (third graph) indicates that the decrease in the elasticity was statistically significant at lower income levels.

If one could extrapolate from 1997 to the future from these estimates, it would appear that future income increases would have almost no impact on whether or not an individual consumes any flour products. The quantity of flour consumed, however, would fall with income increases for those in the lower income levels, where the elasticity is quite negative. But at higher income levels, where the income elasticity approaches zero, there would be no further reductions in flour product consumption. Future income increases could lead to large declines in overall flour product consumption, but would eventually level out.

We conducted a similar analysis for the consumption of rice products. While higher income levels in 1989 led to increased incidences of rice consumption, by 1997 this incidence elasticity was close to zero at all income levels. The decline in the elasticity for higher income levels was statistically significant. Extrapolating from the 1997 elasticity estimates, higher income in the future will not lead to more people consuming rice products. This is nearly identical to the implications for flour consumption, the other staple food analyzed here. The income elasticity for rice consumption tends to be small and insignificant over the entire income range. The results suggest that higher future income will do little to increase the incidence of rice consumption, and the quantity consumed will undergo only small increases at most, and possibly slight decreases. In conjunction with the results we found for flour product consumption, higher future income will lead to overall declines in the consumption of these two staple goods.

Animal food intakes increased as income increased. As seen in Fig. 2a, the probability of consuming any animal foods in 1989 and 1997 was strongly related to increased income, with higher income people being much more likely to consume animal foods. The change in income elasticity, however, was quite small over time. Fig. 2b indicates that the quantity of animal foods consumed, given some consumption, was significantly related to income in both 1989 and 1997, with an elasticity of about 0.4. Again extrapolating from the 1997 results, higher income in the future could lead to many more individuals consuming some animal foods, with more increases in the amount consumed.

Among all animal foods, the difference of income elasticity for the propensity and quantity of pork consumption between low-income and high-income people was not significant. Low-income people had a much higher income elasticity for the propensity of consuming poultry, beef and mutton, and for the quantity of beef and mutton consumed in 1997. Overall, it appears that future income increases may lead to more people consuming chicken, beef and mutton, and there will be quite large increase in the amount of beef and mutton consumed, but slight declines in the amount of chicken consumed.

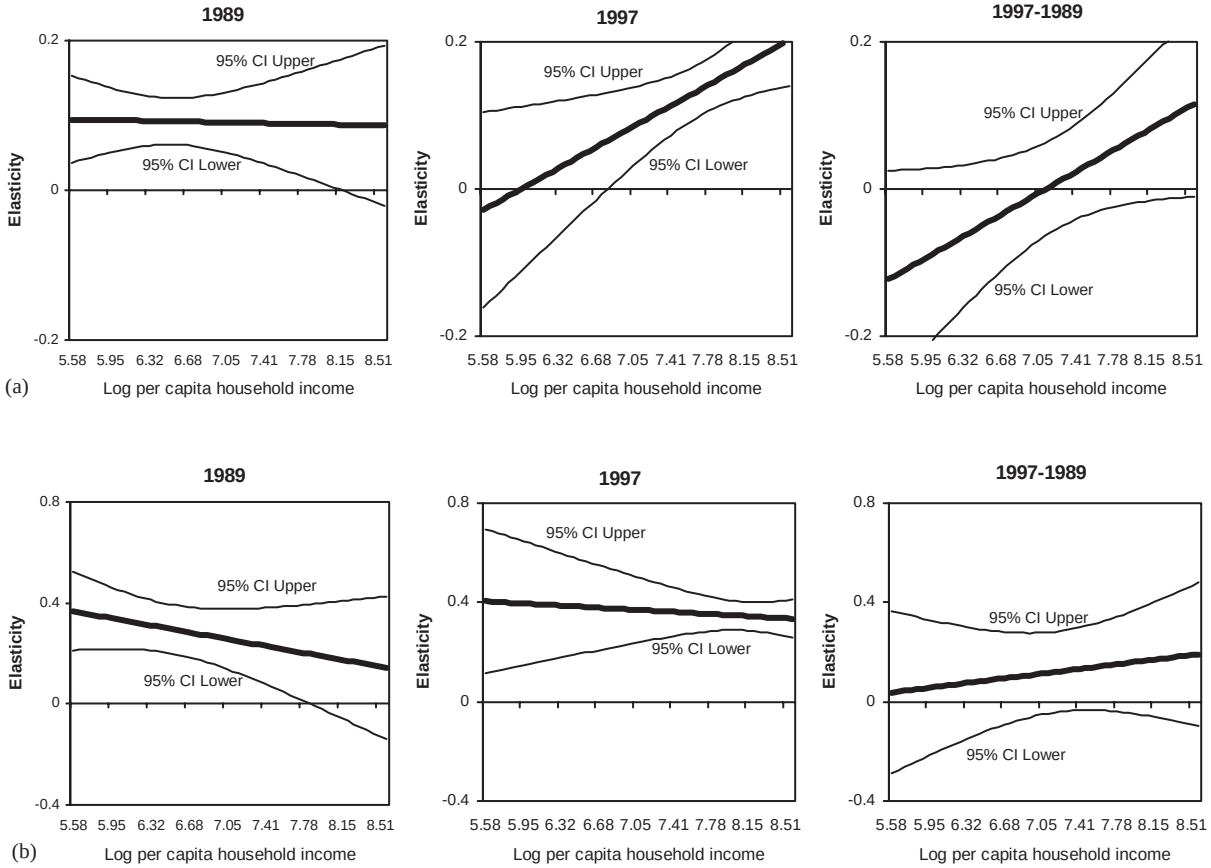

Fig. 2. (a) Income elasticity for the probability of animal food consumption (b) Income elasticity for the quantity of animal food consumption.

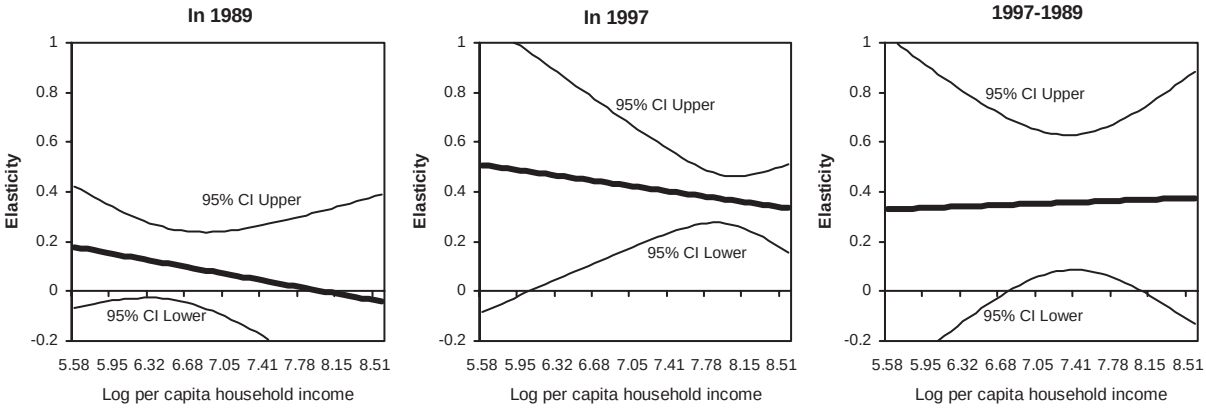

Fig. 3. Income elasticity for the probability of high-fat diet consumption.

Edible oil consumption is inelastic. While the earlier analysis indicated that edible oil consumption comprised a significant fraction of fat consumption, there does not appear to be a strong relationship between edible oil consumption and income. Given that in 1997 nearly everyone consumed some edible oil, our analysis for this food group only focuses on the amount consumed. In both 1989 and 1997, the income elasticity for edible oil consumption was quite small, and in no instance was the elasticity significantly different from zero. The changes of elasticity were not significant. Future income increases might have a slight impact on the consumption of edible oils.

High-fat diets become superior goods at all income levels. Fig. 3 examines the relationship between income and the incidence of a high-fat diet. In 1989, the income elasticity was small and insignificant, and no income level displayed any compelling evidence that higher income would lead to an increased incidence of high-fat diets. By 1997, however, dramatic changes had taken place. The elasticity was about 0.4 over the entire income range, implying that a doubling of income would lead to a 40% increase in the incidence of high-fat diets. The elasticity is significant over nearly all of the income range for 1997, and the changes in elasticity from 1989 to 1997 were significantly different from zero over the middle portion of the income distribution. Extrapolating from the 1997 income effects, future income increases might be associated with large increases in the incidence of high-fat diet.

Discussion

Income change effects. This study provides further evidence that the nutrition transition is accelerating in developing countries and that the burden of disease related to poor diets may be shifting to the poor.

The total energy intake is decreasing among all income groups, a rather unique trend in China, while most other developing countries reported an increasing trend. The energy intake from fat is quickly increasing.

The structure of the Chinese diet is changing with improved income, particularly in the low- and middle-income groups. The Chinese diet is shifting away from traditional foods—rice, wheat and wheat products—toward high-energy density, high-fat and low-fiber diets. People in the low-income group have the highest decrease in cereal food intakes.

The impacts of income changes on dietary behavior differ over time. For example, in 1997 the quantity of beef and mutton consumption would have increased by 20% if people in the low- and middle-income groups received an extra 10% income, while the consumption would not have changed significantly for the same income groups in 1989.

The impacts of income change over time on dietary behavior are also different for the different income levels. For example, the income elasticity for the probability of consuming any poultry increased for all income groups, but the change was much smaller (and insignificant) for those with low income than for those with high income.

These dynamic changes are consistent with those found in other countries. A key issue is the social burden of disease. These results indicate that the poor in China will more rapidly increase their shift into the high noncommunicable disease category than the rich and it is likely that the burden of obesity will begin to shift toward the poor. This result is borne out in cross-country research on this topic.

Increased income effects. This study found that increased income might affect diets and body composition in a manner detrimental to the health of the populations at all income levels, with many of the largest

changes taking place in the lower- and middle-income groups. The poor people in developing countries are following their richer counterparts in making changes to their dietary behavior. These changes seem to be linked with a great potential for poor health.

First, the prevalence of overweight and obesity paralleled the changes of dietary structure seen with increased income. It almost doubled in the eight-year period (1989–1997), even in the low-income groups. China seems to be rapidly relinquishing its traditional staple foods of rice, wheat and wheat products. Edible oil intake increases unabated, as does the intake of other animal products. In China, foods are always stir-fried while cooking; stir-frying has a high potential to add oil, which is one of the reasons that fat intake increases rapidly. The level of fat intake in China is much higher than in South Korea, although China's Gross National Product (GNP) was less than 1/14 the GNP in South Korea in 1996. The overall proportion of energy from fat increased quickly, reaching an overall average of 27.3% and 32.8% for urban residents in 1997, respectively. Over a third of Chinese adults and 60.1% of those in urban areas consumed over 30% of their energy from fat (Du et al., 2002). China is experiencing the nutrition transition much sooner and at a much lower level of GNP than the United States and Western European countries (Drewnowski & Popkin, 1997).

Second, the overall 1999 death rates among urban residents increased to a higher rate than in the early 1970s. The main reason was an increase in mortality from DR-NCD such as CVD, diabetes, and cancers. This shift is astounding, as morbidity and mortality from DR-NCD increased much faster than the decreases from infection and parasite diseases. The latter diseases are already at a very low level and are not expected to disappear within a short time, while it seems there are no limitations for the increase in the former (DR-NCD) and can reach a very high level in a very short time. The cases of CVD in China and India were already greater than the total cases in all other developed nations (Reddy, 2002). DR-NCD have become the major sources of adult death and have resulted in the increases of mortality in China.

We should pay more attention to the poor when we make any nutrition policies, because the poor are more vulnerable to the effects of income change.

First, the current nutrition transition seems to be occurring faster among poor people than among the rich. Food demand in the past was more price- and income-sensitive among the poor than among the rich (Timmer, Falcon, & Pearson, 1984). However, due to the low prices and the affluent food supply, even the poor can afford more fat and animal source foods. In the United States, dietary change exhibits a pattern of health-conscious behavioral change (Popkin, Siega-Riz, & Haines, 1996), but, such a pattern of health-conscious behavior does not seem to be occurring in the developing world. When people—particularly the poor—receive extra income, the first goal is to improve their diet. However, our results verify diet improvement always means extra edible oil, pork, or other meats. Poor people may also have the potential to be exposed to high-fat, high-energy density junk foods (Reidpath, Burns, Garrard, Mahoney, & Townsend, 2002). Many studies reported SES proved to be inversely associated with BMI (Sundquist and Johansson, 1998; Alaimo, Olson, & Frongillo, 2001; Mellor and Milyo, 2001; Marmot, 2001).

Second, physical activities in daily life have been reduced greatly due to advances in technology and transportation (Bell, Ge, & Popkin, 2001). Also, poor people may be more vulnerable to such changes as they have a "lack of social participation". Income could be causally related to health through the effect on social participation and the opportunities to control life's circumstances (Marmot, 2002; Lynch et al., 1998). Although China has achieved remarkable economic progress, income disparity and health inequality have increased. The poor Chinese may not be able to afford leisure activity or physical activity in gyms; as a result, they may spend more time watching TV and playing electronic games. We did not measure physical inactivity in this study. The proportion of TV set ownership can be used to measure changes in daily physical inactivity; clearly TV ownership represents a major potential source of inactivity. The highest increase of TV ownership—from 40% in 1989 to 78% in 1997—was found among the lower-income groups (Du, Lu, Wang, Zhai, & Popkin, 2001).

The Chinese diet is shifting away from the traditional, most healthful diet in the world, toward one that most high-income countries are attempting to change, and other countries may be able to bypass. Multivariate analyses of this study show that extra income is associated with a greater increase in high-fat diets, particularly among the poor. An increased income starts to show its potential detrimental effects on the health of a large population in most developing countries. People in low-income groups are more vulnerable to these effects. Many DR-NCD emerged first in higher SES groups and also declined first in the same groups, such as CHD, CVD, and stroke (Mackenbach, Kunst, Cavelaars, Groenhof, & Geurts, 1997), while the morbidity and mortality still increased in low SES groups. The gap in morbidity and mortality of DR-NCD among SES has widened (Drever, Whitehead, & Roden, 1996; Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993). Health improvements of the last two decades may be reversed if DR-NCD cannot be controlled.

Acknowledgements

This analysis was conducted while Shufa Du was a postdoctoral fellow at the Carolina Population Center, University of North Carolina at Chapel Hill, NC. He received his funding from the Fogarty International Center, National Institutes of Health (NIH) (Grant # 37486). We thank the NIH (R01-HD30880 and R01-HD38700) and the Fogarty International Center, NIH for financial support for the analysis. We also wish to thank Ms. Frances L. Dancy for administrative assistance, Mr. Tom Swasey for graphics support, and Mr. Bill Shapbell for editing assistant.

References

Alaimo, K., Olson, C. M., & Frongillo, E. A. (2001). Low family income and food insufficiency in relation to overweight in US children: Is there a paradox? *Archives of Pediatrics & Adolescent Medicine*, *155*(10), 1161–1167.

Bell, C., Ge, K., & Popkin, B. M. (2001). Weight gain and its predictors in Chinese adults. *International Journal of Obesity and Related Metabolic Disorders*, *25*, 1079–1086.

Block, G., Norris, J. C., Mandel, R. M., & DiSogra, C. (1995). Sources of energy and six nutrients in diets of low-income Hispanic–American women and their children: Quantitative data from HHANES, 1982–1984. *Journal of the American Dietetic Association*, *95*(2), 195–208.

Davison, A. C., & Hinkley, D. V. (1997). *Bootstrap methods and their application*. Cambridge: Cambridge University Press.

Doran, L., & Evers, S. (1997). Energy and nutrient inadequacies in the diets of low-income women who breast-feed. *Journal of the American Dietetic Association*, *97*(11), 1283–1287.

Drever, F., Whitehead, M., & Roden, M. (1996). Current patterns and trends in male mortality by social class (based on occupation). *Population Trends*, *86*, 15–20.

Drewnowski, A., & Popkin, B. M. (1997). The nutrition transition: New trends in the global diet. *Nutrition Reviews*, *55*(2), 31–43.

Du, S., Lu, B., Wang, Z., Zhai, F., & Popkin, B. M. (2001). Transition of dietary pattern in China. *Journal of Hygiene Research*, *30*(4), 221–225.

Du, S., Lu, B., Zhai, F., & Popkin, B. M. (2002). A new stage of the nutrition transition in China. *Public Health Nutrition*, *5*(1A), 169–174.

Efron, B., & Tibshirani, R. J. (1993). *An introduction to the bootstrap*. New York: Chapman & Hall.

Giskes, K., Turrell, G., Patterson, C., & Newman, B. (2002). Socioeconomic differences among Australian adults in consumption of fruit and vegetables and intakes of vitamins A, C and folate. *Journal of Human Nutrition and Dietetics*, *15*(5), 375–385.

Guo, X., Mroz, T. A., Popkin, B. M., & Zhai, F. (2000). Structural change in the impact of income on food consumption in China, 1989–1993. *Economic Development and Cultural Change*, *48*(4), 737–760.

Guralnik, J. M., Land, K. C., Blazer, D., Fillenbaum, G. G., & Branch, L. G. (1993). Educational status and active life expectancy among older blacks and whites. *New England Journal of Medicine*, *329*(2), 110–116.

Haines, P. S., Guilkey, D. K., & Popkin, B. M. (1988). Modeling food consumption decisions as a two-step process. *American Journal of Agricultural Economics*, *70*(3), 543–552.

Inoue, S., & Zimmet, P. (2000). *The Asia–Pacific perspective: redefining obesity and its treatment*. Sydney, Australia: Health Community.

Lynch, J. W., Kaplan, G. A., Pamuk, E. R., Cohen, R. D., Heck, K. E., & Balfour, J. L., et al. (1998). Income inequality and mortality in metropolitan areas of the United States. *American Journal of Public Health*, *88*(7), 1074–1080.

Mackenbach, J. P., Kunst, A. E., Cavelaars, A. E., Groenhof, F., & Geurts, J. J. (1997). Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet*, *349*(9066), 1655–1659.

Marmot, M. (2001). Income inequality, social environment, and inequalities in health. *Journal of Policy Analysis and Management*, *20*(1), 156–159.

Marmot, M. (2002). The influence of income on health: Views of an epidemiologist. Does money really matter? Or is it a marker for something else? *Health Affairs*, *21*(2), 31–46.

Mellor, J. M., & Milyo, J. D. (2001). Income inequality and health. *Journal of Policy Analysis and Management*, *20*(1), 151–155.

Nelson, M. (2000). Childhood nutrition and poverty. *Proceedings of the Nutrition Society*, *59*(2), 307–315.

Popkin, B. M. (2002). The shift in stages of the nutrition transition in the developing world differs from past experiences!. *Public Health Nutrition*, *5*(1A), 205–214.

Popkin, B. M., Paeratakul, S., Zhai, F., & Ge, K. (1995a). Dietary and environmental correlates of obesity in a population study in China. *Obesity Research*, *3*(Suppl. 2), 135s–143s.

Popkin, B. M., Paeratakul, S., Zhai, F., & Ge, K. (1995b). A review of dietary and environmental correlates of obesity with emphasis on developing countries. *Obesity Research*, *3*(Suppl. 2), 145s–153s.

Popkin, B. M., Siega-Riz, A. M., & Haines, P. S. (1996). A comparison of dietary trends among racial and socioeconomic groups in the United States. *New England Journal of Medicine*, *335*(10), 716–720.

Reddy, K. S. (2002). Cardiovascular diseases in the developing countries: Dimensions, determinants, dynamics and directions for public health action. *Public Health Nutrition*, *5*(1A), 231–237.

Reidpath, D. D., Burns, C., Garrard, J., Mahoney, M., & Townsend, M. (2002). An ecological study of the relationship between social and environmental determinants of obesity. *Health Place*, *8*(2), 141–145.

Sharkey, J. R., Branch, L. G., Zohoori, N., Giuliani, C., Busby-Whitehead, J., & Haines, P. S. (2002). Inadequate nutrient intakes among homebound elderly and their correlation with individual characteristics and health-related factors. *American Journal of Clinical Nutrition*, *76*(6), 1435–1445.

Stata Corp. (2001). Stata Statistical Software: Release 7.0. College Station, TX: Stata Corporation.

State Statistical Bureau. (2002). *China Statistical Yearbook 2001*. China: China Statistics Press.

Sundquist, J., & Johansson, S. E. (1998). The influence of socioeconomic status, ethnicity and lifestyle on body mass index in a longitudinal study. *International Journal of Epidemiology*, *27*(1), 57–63.

Timmer, C. P., Falcon, W. P., & Pearson, S. R. (1984). *Food policy analysis*. Baltimore: Johns Hopkins University Press.

WHO. (1990). *Diet, nutrition and the prevention of chronic diseases*. Technical Report Series 797. WHO, Geneva.

WHO. (2002). *Diet, nutrition and the prevention of chronic diseases: report of the joint WHO/FAO Expert Consultation*. WHO, Geneva, 2002. (http://www.who.int/hpr/nutrition/26Aprildraftrev1.pdf), Accessed on 01/09/2003.

World Bank. (2002). *World development indicators 2002*. World Bank, Washington, DC.