THREE PAPERS ON HEALTH AND DEVELOPMENT IN CHINA AFTER THE ECONOMIC REFORMS

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THREE PAPERS ON HEALTH AND DEVELOPMENT IN CHINA AFTER THE ECONOMIC REFORMS

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This dissertation comprises three papers on health and development in China after the economic reforms initiated in early 1980s. The first paper analyzes the relationship between income inequality and health and provides some evidence that income inequality negatively affects population health. The second paper looks at determinants of children's height and shows that a group of individual, household and community factors all play important roles in determining Chinese children's health in the 1990s. The third paper investigates the under-nutrition situation in China along with intra-household inequality. A U-shape relationship is found between intra-household inequality and average household well being, which implies important policy applications. All three papers use the China Health and Nutrition Survey data.

In the first paper, nonparametric techniques are used and a multi-level regression model is applied to analyze data from nine provinces included in the China Health and Nutrition Survey (CHNS) collected in 1991, 1993, 1997 and 2000. The analyses show an independent effect of income inequality on self-reported health after adjusting for individual and household variables. We conclude that in China, societal income inequality appears to be an important determinant of population health during 1991-2000.

The second paper uses longitudinal data from the China Health and Nutrition Survey in the 1990s to study children's height and its socioeconomic determinants. The cohort

in the CHNS shows low scores of height compared to the same age/sex child in the reference. Through the survey years, there are decreased inequalities in height between rural and urban, and between male and female children. A dynamic model is used to observe the effect of past height on current height and is found better in finding the impacts of time-varying variables than a static model, which downplays the importance of time varying variables and over-emphasizes the importance of time-invariant variables. A group of individual, household and community factors are found important for children's height in China.

The last paper finds large scale under-nutrition in the CHNS data from 1991 to 2000 using calorie intake information, as well as nutritional inequalities among various demographic groups. In the analysis of the individual-level data, we find the existence of intra-household inequality in terms of calorie intake. A U-shape relationship is discovered between intra-household inequality and average household well being. Targeting strategies are discussed with a focus on an upper-age-limit targeting scheme. In addition, the uses of individual level data and household level data are compared and the former is found to better analyzing intra-household inequality in China.

BIOGRAPHICAL SKETCH

Xiaofei Pei was born in October, 1978 in Xuyi, a small mountainous town in northern Jiangsu, China. Her parents, both medical doctors, were relocated from the urban to the rural areas during the Culture Revolution. At an early age, Xiaofei witnessed how people's health suffered from a lack of medical resources and public health infrastructure. It was this experience that first developed Xiaofei's sympathy towards the poor and her interest in health.

In 1995, she was enrolled in Nanjing University, where she studied economics. After college, she worked for an international business company for one year before beginning graduate studies in Political Economy at Shanghai Academy of Social Sciences in 2000. She came to Cornell University in 2002 for her Ph.D. in the Department of Policy Analysis and Management, majoring in Health Economics, Development Economics and Epidemiology. She will join her husband, John P. Comeau, in Washington DC, where she hopes to use her expertise and skills in international health and development to help the world's poor and sick.

To my parents, Liqin Shao and Jinlin Pei

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Finally, I would like to thank my parents' for their love and long-distance support over all these years; to my husband's family for their support and love; to many great friends for making my graduate life fun and happy; and finally to my husband, John, for being a wonderful life companion.

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CHAPTER 1

PROVINCIAL INCOME INEQUALITY AND SELF-REPORTED HEALTH STATUS IN CHINA DURING 1991-2000

Abstract

The relationship between income inequality and health has been widely explored. Today there is some evidence suggesting that health status is inversely related with income inequality. This study focuses on China in the 1990s and explores the possible effects of provincial income inequality on individual health status. We use nonparametric techniques and a multi-level regression model to analyze data from nine provinces included in the China Health and Nutrition Survey (CHNS) collected in 1991, 1993, 1997 and 2000. The analyses show an independent effect of income inequality on self-reported health after adjusting for individual and household variables. We conclude that in China, societal income inequality appears to be an important determinant of population health during 1991-2000.

1.1 Introduction

This paper looks at how income inequality affects population health in China during the 1990s. The relationship between income inequality and health status has been widely explored. However, the hypothesis that an individual's health depends not just on the individual's income, but also on relative income (i.e., the distribution of income within the society where individuals reside) has produced mixed results (Craig, 2005; Lynch et al., 2004; Wolfson et al., 1999; Wagstaff et al., 2000). Some United States and cross-national studies have found income inequality significantly and positively related with all cause-specific mortality, life expectancy and self-rated health status, independent of individual poverty levels or median income (Duleep, 1995; Kennedy et al., 1996; Lochner et al., 2001; Shi et al., 2000). However, other studies in Western countries including Japan have failed to find such associations. Subramanian and Kawachi (2004) argue that the reason for the conflicting findings may be that many of these studies focus on countries, such as Japan, Sweden, Denmark, New Zealand and United Kingdom, that are more egalitarian in their distribution of income than the U.S., and that have more comprehensive welfare systems.

Wilkinson and Pickett's (2005) review of the effect of income inequality on health suggests that studies which have not find an association typically used small geographic units rather than large ones (e.g, a community rather than a state). They argue that this is because income inequality is more evident in a larger context than a smaller homogeneous community and therefore a state-wise inequality has more impact on population health than a community-wise inequality. Wilkinson and Pickett conclude that most studies actually support the hypothesis that good health is inversely related with income inequality, when the size of the research units is large enough to demonstrate the inequality level.

Research on income inequality and health in developing countries is scarce, due in part to the lack of quality data. Findings from South American countries, such as Chile, Brazil, and Ecuador, generally support the hypothesis that health is worse in societies with wider income gradients (Subramanian et al., 2003; Pattussi et al., 2001; Larrea and Kawachi, 2005). Chile is a particularly intriguing case because the country has experienced a dramatic increase in income inequality and now has a more unequal distribution of income than the U.S. The Chile study supports the income inequality hypothesis of the independent effect of societal income inequality on poor self-rated health status after adjusting for household income and community income.

China has experienced dramatic economic reforms with similar patterns of decentralization and privatization as observed in Chile. In fact, following the economic reforms initiated in the early 1980s, China has been experiencing one of the fastest-growing income inequalities in the world along with a fast-developing economy. According to the World Bank's World Development Indicators database, annual per capita GDP growth was about 8.6% during the 1990s, while the Gini coefficient grew by 1.5% per year in China during the same time period (Ravallion and Chen, 2004). The Gini coefficient increased from around 0.3 in the early 1980s to 0.38 in 1988 and to 0.42 in 1995. The Gini ratio for China was reported higher than the Gini ratios for India, Pakistan and Indonesia in the 1990s (Khan and Riskin, 1998).

On the other hand, China's health performance has slipped dramatically in the last 20 years when compared to pre-economic reform rates (World Health Report, 1999). Though the Chinese are now enjoying relatively longer life expectancy (over 70 years old) than many developing countries, it appears that most of this achievement was attained before the economic reforms (Project Team of DRC, 2005). New health problems appeared and started threatening the health of the nation after the economic reform. One-third of the world's cigarettes are consumed in China, while the Chinese population accounts for 20% of the world's total. HIV/AIDs cases are rising at a rate of 30% per year. Schitosomiasis, tamed in the 1950s, is again spreading. Tuberculosis, previously under control, is also on the rise. SARS still remains a fear and avian influenza is becoming increasingly problematic. Environmental deterioration and food safety issues are also hurting the general health of the population. Rapid economic growth has not been reflected in increasing public investment in health. Instead, the economic reforms have turned the public-financed and central-planned health system into a more commercialized and decentralized one. The government share among total health spending has steadily declined from 32% in 1978 to 15% in 2002. About 80% of the population did not have health insurance in the 1990s (Ding, 2005). As a result, health inequality is widening. The ratio of female to male Infant Mortality Rate (IMR) increased from 0.9 to 1.3 from 1981 to 1995 (Zhang and Kanbur, 2005). The IMR in selected rural areas was as high as 96.2 deaths per 1000 births, compared with cities where it averaged 20 per 1000 births (Hsiao, 1995). Lower income groups in China bear a disproportionate share of the morbidity burden (Liu et al., 1999). The nutrition intake for the poor also declined in the 1990s (Meng et al., 2004).

Therefore, it is not unreasonable to suppose that there are some associations between the increasing income inequality and deteriorating health situation in China during the 1990s. We believe that, China represents a strong case in the developing world in terms of its changes in inequality and health. Therefore studying China, a country with a similar income inequality pattern as that of the U.S. and Chile, contributes to the literature in this area. In this paper, we examine how income inequality at the provincial level affects individual health using longitudinal data from the China Health and Nutrition Survey in the 1990s. We hypothesize that provincial income inequality has an independent and possibly negative effect on individual health status. In addition, we are also interested in whether individual income mediates the effect of income inequality on health in China.

During the publishing of this paper, another similar study conducted by Li and Zhu (2006) explores the same relationship between income inequality and health in China. Both this study and Li and Zhu's have used the China Health and Nutrition Survey data in the 1990s. The differences between Li and Zhu's study and this study are discussed as follows. First, Li and Zhu uses only one year (1993) of the CHNS data, while this study includes four waves in the 1990s (1991, 1993, 1997, 2000[1]) so that patterns of the association between income inequality and health can be better observed. Second, while income inequality is calculated at the local community level in Li and Zhu's study, we choose to use the provincial level inequality in our analysis in order to observe a more evident effect of income inequality suggested by Wilkinson and Pickett (2006). Third, while Li and Zhu directly assume a quadratic form of the income inequality in their equation, we apply nonparametric smoothing techniques to investigate the shape of this relationship.

1.2 Mechanism and theoretical model

The pathways for the associations between income inequality and health have not been clearly specified in the literature. Some theorize that an unequal society is socially corrosive, has low level of trust and social capital and lead to more discrimination and violence. People with low social status feel they have less control over their lives and work and also feel devalued and inferior (Marmot, 2004). They not only go through chronic stress but also might take on unhealthy behavior such as smoking, drinking and over-eating. For that reason income inequality may have a direct impact on individuals' health by impacting self esteem, increasing stress and undertaking unhealthy behavior (Wilkinson and Pickett, 2005). Income distribution may also indirectly affect health because an unequal society may under-invest in public programs such as welfare benefits for the poor and basic health facilities for the sick (Lahelma et al., 2004).

[1] The 2000 data was collected in 1999.

Subramanian and Kawachi (2004) summarize two effects from income inequality on health: the 'concavity effect' and the 'pollution effect'. The first assumes a concave relationship between income and health. Therefore transferring certain amount of income from the rich to the poor will result in better average health, as the loss in health among the rich is less than the improvement in health among the poor. In other words, a society with a more equitable income distribution has better average health than a society with a less equitable income distribution does. The pollution effect accounts for the contextual effects of income inequality on health. It represents an independent effect that is detrimental to the population health. Testing this independent effect in China is the main purpose of this study.

To examine these effects, a multilevel regression model is used to test the hypothesis:

$$Yij = \beta^*(Xij) + \alpha(Gi) + \mu j + eij$$

where individual "j" in society "i" has health status "*Yij*", which is affected by both the income at the individual level (Xij) and income inequality at the societal level (Gi). Provincial income inequality was chosen to make the study comparable to previous studies, where significant results are found at the state level. Therefore, β^* captures the "micro" between-individual-within-province income effect, α captures the "macro" between-province income effect (i.e., societal income inequality). u and e are error terms.

Marmot and Wilkinson (2001) argue that it is relative social status, reflected by income inequality that influences health through psychosocial pathways. In that sense, both absolute income and relative income can serve as proxies for social status and the distinction between absolute income and relative income can become weaker. Therefore, it is difficult to draw a clear distinction amid the "macro" "between" effect and the “micro” “within” effect. In other words, both absolute and relative income may include some pollution effect. That is why Wilkinson and Pickett argue that including both absolute income and relative income could therefore over-control for the effect of inequality. In this study, we argue for a more conservative approach by including both income levels into our model. If our results suggest an effect of income inequality after controlling for absolute income, there is clearly a pollution effect, which has been underestimated.

We acknowledge that while there is a vast literature supporting the income inequality hypothesis, there are also voices remain skeptical. For example, some studies include a variety of control variables, such as education (Muller, 2002) and ethnicity (Blakely, Atkinson, and O’Dea, 2003; Deaton and Lubotsky, 2003), and fail to find a relationship between income inequality and health. Subramanian and Kawachi (2004) argue that it is important to know which of these control variables are genuine confounders and which are pathway, or mediating variables since some of them is part of social class, which play a similar role as income inequality does. For example, if ethnicity is related to health because it is a proxy for a classification by class, then perhaps we should not control for ethnicity. Wilkinson and Pickett (2005) argue that what matters is the extent of social class differentiation. No one suggests that it is blackness itself which matters. Rather it is the social meaning attached to it, and the fact that it serves as a marker for class and attracts class prejudice, which leads to worse health and to wider income inequality.

Therefore, our model tests the following hypothesis: societal inequality, in terms of provincial-level income inequality, increases the likelihood of reporting fair and poor health status for individuals regardless of their own income in China between 1991 and 2000.

1.3 Data

We used pooled data from the China Health and Nutrition Survey (CHNS), years 1991, 1993, 1997 and 2000. The CHNS is a longitudinal survey conducted by Carolina Population Center at the University of North Carolina at Chapel Hill, the Chinese National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. CHNS contains 6 waves (1989, 1991, 1993, 1997, 2000 and 2004) and has collected self-reported health data since 1991. The recently released 2004 data are not included in this analysis since we are more interested in the period of the 1990s[2].

The data were collected using a multistage random cluster process from nine provinces that vary considerably in geographic locations, economic development, public resources, and health indicators. Detailed information on health and income was collected. Although the survey was not designed to be representative of the Chinese population, it does provide a sufficient range of values for a sample large enough to correctly model and estimate general behavioral relationships in China during the survey years (Henderson et al., 1998). Two of the nine provinces in the CHNS data are omitted due to incomplete information[3]. In total, our pooled sample includes 17,035 individuals, aged 15 and above, from 4,178 households within 180 communities across 7 Chinese provinces. While some households were included only in one of the four survey years, others participated in two, three or four of the surveys.

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[2] All four waves we use were collected in the 1990s. The 2000 data was collected in 1999.
[3] One province, Liaoning, dropped out of the survey after 1993 and a new province, Heilongjiang joined the survey in 1997.

The dependent variable in this model is self-reported health status. Studies have shown that self-reported health status is a predictive measure of mortality, independent of other medical, behavioral, and psychosocial factors (Krause and Jay, 1994). The CHNS asks individuals, "how would you describe your health compared to that of other people your age?" The response options include excellent, good, fair, and poor. In order to make this study comparable to previous studies of self-reported health studies, we recode the four categories into a dichotomous outcome of self-rated health where 0 equaled "excellent and good" health; and 1 equaled "fair and poor" health. On average, about 28.1% of sample respondents reported "fair and poor" health (i.e., 26.5% in 1991, 26.1% in 1993, 25.2% in 1997 and 35.9% in 2000), while the remainder reported "excellent and good" health. Table 1.1 shows the description of the data.

Individual socioeconomic predictors of self-reported health status include age, gender, marital status, education attainment, health insurance. Since children and younger adolescents are not included in our analysis, the average age in our sample is 42. Females compose 52% of the sample. Almost 72% of the individuals are married. Average education is six years of primary education. About 25% individuals have health insurance.

Household predictors include household residential affiliation, household income, household official affiliation and household access to tap water. Sixty-eight (68.34%) percent of households in the sample live in rural areas. Average household income is about 5767 yuan per year, and per capita income is 1503 yuan per year. We categorize the logarithm of per capital income, as it exhibits a normal distribution, into six groups (i.e., very poor, poor, low, middle, high, and very high) using mean and standard deviation. Two standard deviations or more below the mean is grouped as "very poor"; from two standard deviations below the mean to one standard deviation below the mean is "poor", and from one standard deviation below the mean to the mean is "low". Similarly, we create "middle", "high", and "very high" income groups. Individuals are also asked if any of their family members are employed in the government, which usually means better access to welfare and other resources. Roughly 5% of the households have official affiliation. Access to tap water is also important to health in developing countries. About 66% of the households have tap water in our sample.

Table 1.1 Descriptive Statistics for three different samples

	All 1991-2000		All 1997-2000		Urban 1991-2000	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Poor Health	0.28	0.45	0.30	0.46	0.31	0.46
Gini	35.14	1.60	35.11	1.60	20.24	1.47
Age	41.52	16.83	42.75	16.89	43.17	17.14
Female	0.52	0.50	0.51	0.50	0.52	0.50
Married	0.72	0.45	0.72	0.45	0.73	0.44
Education	13.21	10.22	10.79	10.36	14.17	10.80
Offical	0.17	0.52	0.18	0.54	0.20	0.52
Insurance	0.27	0.47	0.27	0.48	0.47	0.53
Rural	0.68	0.47	0.67	0.47	0.00	0.00
Tap Water	0.66	0.47	0.71	0.45	0.90	0.31
HH Size	3.14	1.30	3.11	1.26	3.07	1.22
Per Capita Income	1514.81	1135.93	1535.54	1193.09	1996.40	1265.34
Valid N	N=32899		N=16690		N=10316	

Income inequality is measured by the Gini coefficients at the provincial-level. Due to the difficulty of getting appropriate data, there are very few studies on the provincial-level Gini coefficients in China despite a large body of income inequality study at the national and regional levels[4]. We borrow the results from Xu and Zou's (2000) study

[4] Regions are usually categorized as east, west, central regions etc. For example, see Fujita and Hu (2001).

in which the means of Gini coefficients by province were calculated for the period 1985 to 1995 using a data set from the World Bank. The time period of the average Gini coefficients in this study corresponds well to the time period of our study (from 1991 to 2000). Moreover, in the sense that the Gini ratios are from five years earlier, the effect of income inequality could be appropriate because of a possible 'lag effect' between income inequality and health suggested by Mellor and Milyo (2003). Xu and Zou's Gini coefficients, however, are based on a largely urban sample, therefore, are more appropriate to be applied to the urban population only. For that reason, we calculate provincial Gini coefficients from the CHNS data despite the fact that CHNS is not nationally representative. The CHNS Gini coefficients we use in the study are calculated averages of the Gini in earlier years of the survey period from1989-1993, in order to catch the "lag effect" mentioned above. Although the pattern of the two sets of Gini ratios are similar (The Pearson correlation is .7 at a significant level of .001), the Gini values from the CHNS data are significantly larger than the Gini values from Xu and Zou's study. This is because Gini from Xu and Zou's study is only for the urban areas and inequalities are generally found larger in rural areas than in urban areas (Ravillion and Chen, 2004). Therefore, we use Gini from Xu and Zou's results to study the urban sample for all four waves (1991, 1993, 1997 and 2000) and use Gini coefficients from CHNS 1989 to 1993 to study the whole sample (both rural and urban) in 1997 and 2000. We do not calculate Gini coefficients separately for urban and rural areas in each province since we believe that the difference between rural and urban areas is part of the inequality we want to observe. Therefore, in the following analysis, unless mentioned, only urban population is considered when Xu and Zou's Gini coefficients are used, and both urban and rural population are considered when the CHNS Gini coefficients are used.

1.4 Nonparametric Analysis

Since the relationship between income inequality and health is still under discussion in the literature, we decide to use non-parametric analysis to test the possible association between the two. Nonparametric methods have the advantage of not imposing functional forms on the data (DiNardo and Tobias, 2001; Fan, 2001). They are useful in providing a crude idea of the interested relationship, and are thus able to provide a direction for the specification of parametric models. Several types of kernel functions are commonly used: uniform, triangle, epanechnikov, quartic(biweight), tricube (triweight), gaussian, cosinus. Gaussian kernels are used in estimation with a 0.8 bandwidth. Alternative specifications of other functions and bandwidths do not result in substantially different relationships.

Figures 1.1 and 1.2 show the results of the kernel regression procedures expressing probability of reporting poor health as functions of Gini coefficients. Both use income inequality in an earlier period to account for the lag effect of income inequality. Figure 1.1 uses the Gini coefficients we borrow from Xu and Zou's study from 1985 to 1995 (see more details in the later session) and reported health from 1991 to 2000. Figure 1.2 uses the Gini coefficients calculated from the CHNS data from 1989 to 1993 and reported health from 1997 to 2000. As can be seen, data from both Xu and Zou's study and the CHNS lead to an inverted-U relationship between income inequality and health.

Although these regression do not control for other factors that may impinge on the health-income inequality relationship, they seem to broadly indicate that the probability to report poor health increases with income inequality before income inequality reach to a certain level and then decreases. Even though some minor changes of slope can be detected in the figures, it appears that it would be reasonable to characterize the relationships as quadratic. Therefore, in the following regression analysis, we apply a quadratic term of income inequality in the equation.

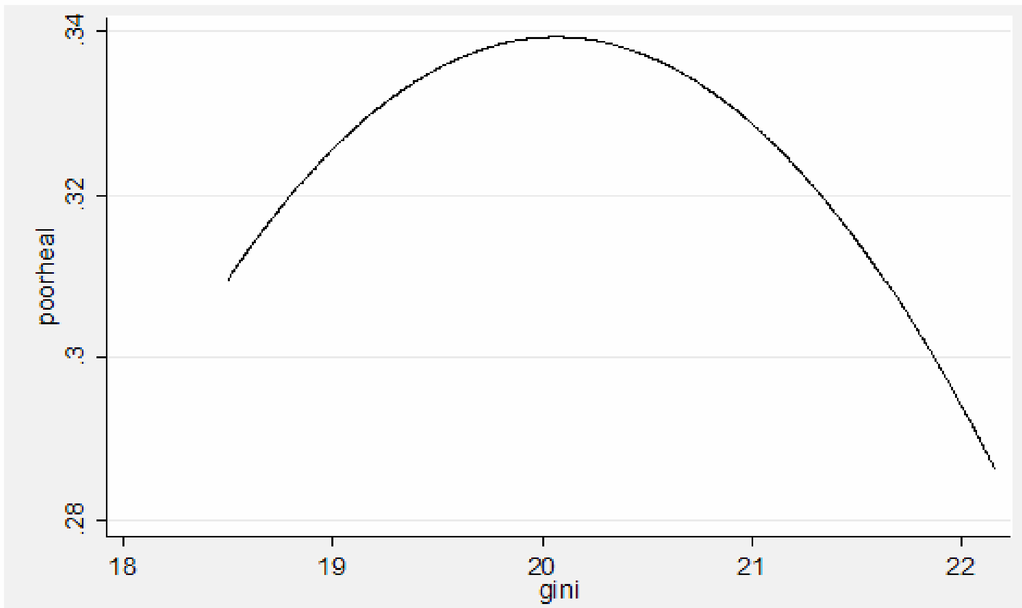

Figure 1.1Kernel regression with BW=.8 for the urban sample 1991-2000 using Gini from Xu and Zou

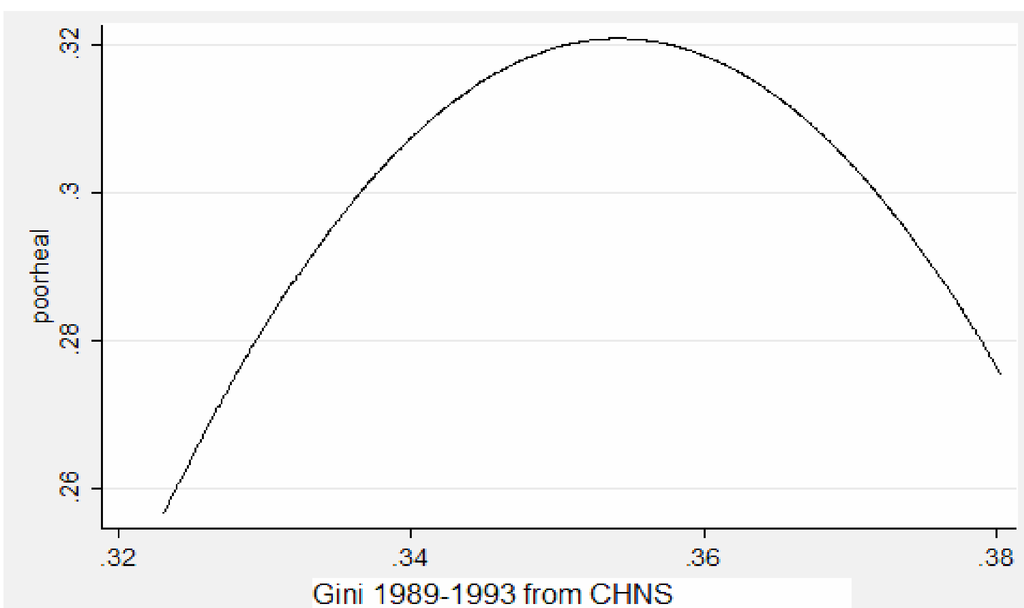

Figure1.2Kernel regression with BW=.8 for total sample 1997-2000 using Gini from CHNS 1989-1993

1.5 Results

Multilevel logit regression analyses are used to test our hypothesis with pooled and individual year data. The SAS PROC Glimmix procedure fits logistic regression models for binary or ordered categorical responses in multi-level models (Littell et al., 1999). In our study, this PROC Glimmix is used to estimate the binary response variable (poor and fair health, or good and excellent health) in a three-level model, i.e., individual-level, household level and provincial-level[5]. Also in our analysis, repeated observations from the same household head were weighted, to assure that multiple years observations had the same relative weight as single year observations. Correlation and collinearity analysis are used to assess the appropriateness of including both income and income inequality in the model. Neither is problematic.

To examine the relation between provincial income inequality and self-reported health, we use three logistic regression models, the results of which are shown in Table 1.2. All three models give the multivariate odds ratios of reporting poor and fair health fully adjusting for individual age, gender, marital status, education attainment, residential affiliation, official affiliation, health insurance, household access to tap water and household size. All three contain a quadratic form of income inequality in the model and consider the lag effects of income inequality on health as the first two use Gini from 1985 to 1995 to predict health in 1991-2000 and third model uses Gini from 1989 to 1993 to predict health in 1997 and 2000. Model 1 does not adjust for individual income and the Gini ratios are from Xu and Zou's study. Model 2 includes individual income and the Gini ratios are same as in Model 1. Model 3 also includes individual income, but the Gini ratios are calculated from the CHNS data.

[5] Since we are looking at the effect of a provincial-level variable (Gini coefficient), it is more appropriate to control for province-level variability. A multilevel model can account for different factors and different sources of variability at individual, household and provincial- level.

Table1.2: Three multi-level logistic models along with significance, odds ratios (OR) and 95% Confidence Interval

	Model 1: without income						Model 2: with income and Gini from Xu and Zou					
Variables	Estimate	S.E.	Sig.	OR	95.0% C.I.		Estimate	S.E.	Sig.	OR	95.0% C.I.	
					Lower	Upper					Lower	Upper
AGE	0.0364	0.0016	3E-109	1.0371	1.0337	1.0404	0.0364	0.0016	7E-109	1.037	1.0337	1.0404
Female	0.1542	0.0465	0.0009	1.1667	1.0651	1.278	0.1584	0.0465	0.0007	1.1716	1.0695	1.2836
Marital	0.0199	0.0565	0.7248	1.0201	0.9132	1.1395	0.0201	0.0565	0.7218	1.0203	0.9133	1.1399
Education	-0.0056	0.0033	0.0916	0.9945	0.9881	1.0009	-0.0048	0.0033	0.1476	0.9952	0.9888	1.0017
Official	-0.1643	0.0877	0.0611	0.8485	0.7145	1.0076	-0.1414	0.0879	0.1077	0.8681	0.7307	1.0314
Insurance	0.1443	0.0511	0.0048	1.1553	1.0451	1.2771	0.1815	0.0524	0.0005	1.199	1.0821	1.3286
Rural												
Tap water	-0.0327	0.0774	0.6732	0.9679	0.8316	1.1265	0.0032	0.0783	0.9671	1.0032	0.8604	1.1697
Famsize	-0.0393	0.0196	0.0453	0.9615	0.9252	0.9992	-0.043	0.0197	0.029	0.9579	0.9216	0.9956
Income												
Very Poor									0.0038			
Poor							-0.0879	0.158	0.578	0.9159	0.672	1.2482
low							-0.2699	0.15	0.0719	0.7635	0.569	1.0244
Middle							-0.323	0.1479	0.029	0.724	0.5418	0.9674
High							-0.3449	0.1486	0.0202	0.7083	0.5294	0.9477
Very high							-0.473	0.1607	0.0032	0.6231	0.4548	0.8538
Gini												
Gini	13.308	2.225	2E-09	602102	7687.3	5E+07	14.466	2.2658	2E-10	2E+06	22576	2E+08
$Gini^2$	-0.3267	0.0546	2E-09	0.7213	0.6481	0.8028	-0.355	0.0556	2E-10	0.7012	0.6287	0.7819
Constant	-136.99	22.514	1E-09	3E-60			-148.46	22.924	9E-11	3E-65		

	Model 3: with income and Gini from CHNS					
Variables	Estimate	S.E.	Sig.	OR	95.0% C.I.	
					Lower	Upper
AGE	0.0397	0.0013	2E-216	1.0405	1.0379	1.0431
Female	0.2056	0.0372	3E-08	1.2283	1.1419	1.3211
Marital	-0.0463	0.0449	0.303	0.9548	0.8743	1.0427
Education	-0.0097	0.003	0.0012	0.9904	0.9846	0.9962
Official	-0.1201	0.0914	0.1885	0.8868	0.7414	1.0607
Insurance	0.0839	0.0491	0.0873	1.0875	0.9878	1.1973
Rural	-0.3859	0.0425	1E-19	0.6798	0.6255	0.7388
Tap water	-0.2422	0.0445	5E-08	0.7849	0.7194	0.8564
Famsize	-0.0713	0.0154	4E-06	0.9312	0.9035	0.9598
Income						
Very Poor			6E-08			
Poor	-0.0989	0.0831	0.2338	0.9058	0.7697	1.066
low	-0.2092	0.0821	0.0109	0.8112	0.6906	0.9529
Middle	-0.2915	0.0834	0.0005	0.7471	0.6344	0.8799
High	-0.4264	0.0873	1E-06	0.6529	0.5502	0.7747
Very high	-0.4622	0.1094	2E-05	0.6299	0.5083	0.7806
Gini						
Gini	22.815	4.2822	1E-07	8E+09	2E+06	4E+13
$Gini^2$	-0.3046	0.0574	1E-07	0.7374	0.659	0.8252
Constant	-427.94	79.698	8E-08	1E-186		

All regressions include provincial indicators and year indicators.

In all three models, both Gini and Gini squared are statistically significant, indicating that income inequality has an effect on reporting poor health. All three show positive coefficients on the Gini and negative coefficients with respect to Gini squared, signifying that there is an inverted U-shape between income inequality and the probability of reporting poor health. In other words, the probability of reporting poor health increases with income inequality and after it reaches a certain level it starts decreasing. In Model 1 the critical point is 20.35%, which is greater than 57% of the sample. Therefore, it seems that without adjusting for individual income, income inequality increases the probability of reporting poor or fair health for the majority in the studied sample. Model 2 shows that after adjusting for individual income, the turning point becomes 20.37%, slightly higher than the previous critical point. In other words, even after adjusting for individual income, the effect of income inequality stays almost unchanged. Using Gini from the CHNS data in 1989-1993 in Model 3, similar results are found after adjusting for individual income. The critical point in Model 3 is 37.41%, significantly higher than in the previous two models, suggesting that the inequality level is higher in Model 3. More than 80% of the CHNS sample has a Gini coefficient less than the critical point , suggesting that the majority of the sample are on the left hand side of the critical point, with increasing probability of reporting poor health with changes in Gini coefficients.

We also separate the nine provinces into 3 groups (high income-inequality, middle income-inequality, low income-inequality) according to their Gini coefficients, we find that people from a higher income inequality group experience approximately 5-10% more risk of reporting poor health compared to those from a lower-income-inequality province. In short, the results from the three models in Table 1.2 indicates that after adjusting for the effect of individual income, there is still an independent effect of income inequality from 1991 to 2000 in our sample. The effect of income inequality, before it reaches a relatively high level, increases the probability of reporting poor and fair health.

We also analyze the possible effect of income inequality in each of the individual survey waves. Table 1.3 shows the results using Gini from Xu and Zou and Table 1.4 with Gini from CHNS. As is seen in Table 1.3, a U-shape relationship consistently appears through all survey years. The turning points in each wave are 20.33, 20.29, 22.10 and 20.21 in 1991, 1993, 1997 and 2000, consecutively. In other words, the critical point remains relatively constant through the survey years with a slight increase in 1997. The probability of reporting poor and fair health increases with Gini when it is less than these turning points (which includes 57% of the sample) and decreases with inequality larger than the turning points (which include the rest 43% of the sample). Again these results suggest that for the majority of the sample, our hypothesis holds in the sense that income inequality increases probability of reporting poor and fair health.

Table 1.3 By year: multilevel logistic regression using Gini from Xu and Zou, along with significance, odds ratios and 95% Confidence Interval

	Year 1991						Year 1993					
Variables	Estimate	S.E.	Sig.	OR	95.0% C.I.		Estimate	S.E.	Sig.	OR	95.0% C.I.	
					Lower	Upper					Lower	Upper
AGE	0.0395	0.0038	5E-25	1.0403	1.0326	1.0482	0.0418	0.004	8E-26	1.0427	1.0346	1.0509
Female	0.1405	0.1003	0.1612	1.1509	0.9455	1.4009	0.0742	0.1052	0.4809	1.077	0.8763	1.3237
Marital	0.1893	0.1236	0.1256	1.2085	0.9485	1.5397	-0.157	0.1271	0.2174	0.8549	0.6664	1.0967
Education	-0.006	0.0065	0.3787	0.9943	0.9817	1.0071	0.0007	0.0071	0.9215	1.0007	0.9868	1.0148
Official	-0.133	0.1964	0.4969	0.8751	0.5955	1.2859	-0.332	0.2113	0.1161	0.7175	0.4742	1.0856
Insurance	0.115	0.1144	0.3144	1.1219	0.8966	1.4038	0.1538	0.1193	0.1974	1.1662	0.9231	1.4733
Tap water	-0.135	0.1482	0.3614	0.8735	0.6533	1.1679	0.5554	0.1822	0.0023	1.7427	1.2193	2.4908
Famsize	-0.064	0.0402	0.1125	0.9382	0.8671	1.0151	0.0058	0.0434	0.8941	1.0058	0.9238	1.0951
Income												
Very Poor			0.1948						0.0094			
Poor	0.4101	0.4045	0.3106	1.507	0.6821	3.3296	-0.595	0.3208	0.0635	0.5515	0.2941	1.0341
low	0.0071	0.3746	0.9848	1.0072	0.4833	2.0987	-0.592	0.3115	0.0575	0.5535	0.3006	1.0191
Middle	0.1699	0.3708	0.6467	1.1852	0.573	2.4514	-0.776	0.3039	0.0106	0.4601	0.2536	0.8347
High	0.2924	0.3731	0.4333	1.3396	0.6447	2.7835	-0.514	0.3048	0.0918	0.5981	0.3291	1.0871
Very high	-0.03	0.4046	0.9407	0.9704	0.4391	2.1443	-1.075	0.3453	0.0019	0.3413	0.1734	0.6715
Gini												
Gini	16.22	4.8348	0.0008	1E+07	848.86	1E+11	41.073	5.6721	4E-13	7E+17	1E+13	5E+22
Gini squared	-0.399	0.1188	0.0008	0.6708	0.5314	0.8468	-1.012	0.1393	4E-13	0.3636	0.2767	0.4777
Constant	-166.5	48.861	0.0007	5E-73			-416.9	57.41	4E-13	9E-182		

	Year 1997						Year 2000					
Variables	Estimate	S.E.	Sig.	OR	95.0% C.I.		Estimate	S.E.	Sig.	OR	95.0% C.I.	
					Lower	Upper					Lower	Upper
AGE	0.0361	0.0033	1E-27	1.0367	1.03	1.0435	0.0355	0.0032	8E-28	1.0361	1.0295	1.0427
Female	0.1417	0.0888	0.1105	1.1523	0.9682	1.3714	0.282	0.0889	0.0015	1.3257	1.1137	1.5781
Marital	-0.023	0.1067	0.8292	0.9772	0.7929	1.2045	0.0759	0.109	0.4862	1.0788	0.8714	1.3358
Education	-0.007	0.0061	0.2857	0.9935	0.9816	1.0055	-0.044	0.074	0.5508	0.9568	0.8277	1.1061
Official	-0.161	0.1606	0.3155	0.8511	0.6213	1.1659	0.0229	0.1631	0.8882	1.0232	0.7433	1.4085
Insurance	0.1531	0.0995	0.1239	1.1654	0.959	1.4163	0.2574	0.1029	0.0123	1.2935	1.0574	1.5824
Tap water	-0.025	0.1725	0.884	0.9751	0.6953	1.3675	-0.015	0.1585	0.9258	0.9853	0.7222	1.3444
Famsize	-0.035	0.0372	0.3454	0.9655	0.8977	1.0385	-0.068	0.0437	0.1212	0.9345	0.8577	1.0181
Income												
Very Poor			0.0597						0.0001			
Poor	1.2313	0.5187	0.0176	3.4256	1.2394	9.4677	-0.212	0.2506	0.3974	0.8089	0.495	1.3219
low	1.3179	0.5071	0.0094	3.7355	1.3827	10.092	-0.599	0.2373	0.0115	0.5492	0.3449	0.8744
Middle	1.1514	0.5046	0.0225	3.1626	1.1762	8.5034	-0.593	0.2344	0.0115	0.5528	0.3492	0.8752
High	1.0272	0.5044	0.0417	2.7933	1.0394	7.5072	-0.903	0.24	0.0002	0.4052	0.2532	0.6485
Very high	1.0808	0.5157	0.0361	2.9471	1.0727	8.0971	-0.832	0.2632	0.0016	0.4351	0.2597	0.7289
Gini												
Gini	2.2095	4.3538	0.6118	9.1108	0.0018	46293	13.502	4.1545	0.0012	731102	212.64	3E+09
Gini squared	-0.05	0.1069	0.641	0.9514	0.7716	1.1731	-0.334	0.102	0.0011	0.7161	0.5863	0.8745
Constant	-27.75	44.025	0.5284	9E-13			-137.5	42.028	0.0011	2E-60		

All regressions include provincial indicators.

Table 1.4 shows that if we use Gini from the CHNS data in early years to predict health in later years, the effect of the Gini coefficients on health remains statistically significant for each of the later years (1997 and 2000). The critical point decreases a little bit from 37.49% in 1997 to 37.40% in 2000, which still includes more than 80% of the provinces in the sample. Therefore, the majority of the CHNS sample experiences increasing risk of reporting poor health with increases in income inequality. Less than 20% of the sample that has a higher Gini coefficients experience decreasing risk from income inequality.

In a separate analysis, we included Gross Domestic Product (GDP) per capita in each province in our model for years 1993 and 1997[6] to control for a broader measure of standard of living in addition to individual income. We found that the odds of the effect of income inequality were attenuated but still remained positive and significant, showing that despite different levels of GDP per capita in each province, the effect of income inequality on the risk of reporting poor health remains at the individual level.

Besides provincial income inequality, we also find that individual income matters in terms of health status. As individual income increases, the probability of reporting lower levels of health status decreases in all the models we run. For example in Table 1.2, in terms of reporting poor and fair health, the probability of the highest income group is 62%% in Model 2 and 63% in Model 3, of the lowest income group. Even after controlling for GDP per capita at the provincial-level, the pattern does not change.

[6] 1993 GDP per capital is from Lee's 2000 article, see reference. 1997 GDP per capital is from: http://www.uschina.org/statistics/regionalstats.html While we mention this additional analysis, we chose not to report on a more detailed analysis because the accuracy of GDP data available is still under scrutiny.

Table 1.4 By year: multilevel logistic regression using Gini from CHNS, along with significance, odds ratios and 95% Confidence Interval.

	Year 1997						Year 2000					
Variables	B	S.E.	Sig.	Exp(B)	95.0% C.I.for EXP(B)		B	S.E.	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
AGE	0.037	0.002	0.000	1.038	1.034	1.042	0.041	0.002	0.000	1.042	1.038	1.046
Female	0.084	0.054	0.118	1.088	0.979	1.208	0.315	0.053	0.000	1.370	1.234	1.521
Marital	-0.054	0.062	0.384	0.947	0.839	1.070	-0.040	0.067	0.549	0.960	0.841	1.096
Education	-0.015	0.004	0.000	0.985	0.978	0.992	-0.019	0.045	0.673	0.981	0.898	1.072
Official	-0.117	0.126	0.353	0.890	0.695	1.138	-0.074	0.135	0.586	0.929	0.713	1.211
Insurance	0.043	0.068	0.530	1.044	0.913	1.194	0.162	0.072	0.025	1.175	1.021	1.353
Rural	-0.469	0.061	0.000	0.625	0.555	0.704	-0.325	0.060	0.000	0.722	0.642	0.813
Tap water	-0.440	0.062	0.000	0.644	0.571	0.727	-0.026	0.065	0.685	0.974	0.858	1.106
Famsize	-0.082	0.021	0.000	0.922	0.885	0.960	-0.059	0.024	0.013	0.942	0.899	0.987
Income												
Very Poor			0.005						0.000			
Poor	-0.210	0.134	0.116	0.810	0.624	1.053	-0.028	0.108	0.796	0.973	0.788	1.201
low	-0.149	0.131	0.253	0.861	0.667	1.112	-0.327	0.108	0.002	0.721	0.583	0.891
Middle	-0.263	0.133	0.048	0.769	0.592	0.997	-0.366	0.109	0.001	0.694	0.560	0.859
High	-0.407	0.138	0.003	0.666	0.508	0.872	-0.494	0.116	0.000	0.610	0.487	0.766
Very high	-0.469	0.167	0.005	0.626	0.451	0.868	-0.550	0.149	0.000	0.577	0.430	0.773
Gini												
Gini 89-93	32.243	6.317	0.000	1.007E+14	422446881	2.399E+19	12.568	5.914	0.034	287232.09	2.654	3.109E+10
Gini 2	-0.430	0.085	0.000	0.651	0.551	0.768	-0.168	0.079	0.034	0.845	0.723	0.987
Constant	-604.631	117.587	0.000	0.000			-236.128	110.063	0.032	0.000		

Both regressions include provincial indicators.

Other variables that are significant in our sample include age, gender, education, official affiliation, residential affiliation, household size and household access to water. In short, old age, being female, low education, no official affiliation, being urban, smaller family size and no access to tap water in the household, all increase the probability of reporting poor and fair health. Increase in family size decreases the probability of reporting poor health in all three models, which is a little bit surprising and may warrant future study. Marital status is found not significant in all models, which is probably because most of the sample in our study is married (72%). Household access to tap water is found significant in the total sample, but not in the urban sample, suggesting that tap water may be more important in the rural areas than in the urban areas. Official affiliation is significant in the total sample, but not rural sample, which may suggest that urban government employees have more access to resources than rural government employees and therefore their official affiliations are able to show an impact on their health.

1.6 Discussion

In this study, we find evidence of an independent effect of income inequality on self-reported health status after adjusting for potential confounding individual-, household- and provincial-level variables in China during the period 1991 to 2000. In our analysis, we use two sets of Gini ratios to compliment each other. The patterns of the income inequality are similar in each but the magnitudes are different. Using the Gini results from both Xu and Zou's study and the CHNS data, we find a U-shape relationship between income inequality and health as the risk of reporting poor and fair health increases to a critical point and then decreases. The majority of the sample (57% and 80%) falls into the group where income inequality increases the probability of reporting poor and fair health. Compared to those living in provinces with modest income inequalities, the odds of reporting poor and fair health are 5-10% more in provinces with higher income inequality. Across the survey years from 1991 to 2000, the effect of income inequality on health is consistent and similar and the critical point remains relatively constant.

While there is a decreasing part of the inverted U in our sample, it does not necessary imply that increased income inequality is good for health. According the to the results in Model 2 and Model 3, in order to pass the critical point of the inverted-U, the inequality has to reach a very high level, where the majority of the provinces are not included. Therefore, for most of the provinces, the relationship holds that income inequality negatively affects population health. However, using the Gini ratios from

Xu and Zou's study, there are still 3 provinces out of the total 7 provinces that experience decreasing risk of reporting poor health with increase in income inequality. These three provinces are Guizhou, Henan and Hunan, all of which are middle- or low-developed provinces compared to the other provinces. One possible reason for these unexpected results might be that the data we use are from urban areas only and therefore does not reflect the true inequality situation. Another reason could be that the urban sample from these provinces might have a much lower risk of reporting poor health; therefore, even the urban sample experience low risks of reporting poor health, the rural sample might not. The higher inequality in the urban areas might hide the fact that there are even higher inequality levels between rural and urban in these provinces. For Gini coefficients from the CHNS sample, the only province experience a downward sloping relationship between income inequality and poor health is Hunan (Gini=38.03%), a province that is rather low in its economic indexes such as GDP per capita and public health development. Therefore, the better health reporting in Hunan province might just be an anomaly. In fact, if the province of Hunan is not included in the model, the relationship between Gini coefficient and self-reported health is rather a linear than quadratic and it is positive with an odds ratio of 1.11.

Also our findings do not render absolute individual income unimportant. On the contrary, individual income is found strongly and consistently associated with health status over time. Policy makers should take both effects into consideration instead of either one in isolation. Other variables including age, gender, education, official affiliation, residential affiliation (i.e., living in rural or urban areas), household size and household access to tap water (especially in rural areas) also have an impact on self-reported health status. This suggests that vulnerable groups warrant more attention (e.g., the elderly, females, less educated, rural etc.), since these groups also suffer more from the negative effect of the contextual and societal inequalities in our study.

Our model may over-control for the effect of income inequality on health. This is because that beside relative income, individual income could also serve as an indicator for social status and therefore contain some pollution effect as previous studies have suggested (Willkinson and Pickett, 2005; Marmot, 2004). A similar argument could apply in terms of residential affiliation since living in rural or urban areas also indicates different social status in China. Typically, people living in urban areas enjoy better social welfare than those living in rural areas. But our study shows that even controlling for several important socioeconomic variables, the effect of inequality on health related with income remains. Future studies may consider using different measures of inequality in contemporary China and examine their impacts on health.

Due to data limitations, we did not check the possible psychosocial pathways connecting inequality to ill health. But the fact that suicide became the fifth most important cause of death in China during the 1990s, does suggest a plausible explanation (Phillips et al., 2002). Similar psychosocial behavior connecting inequality to ill health include the dramatic increase of smoking and alcohol drinking behavior in China, which could also be due to the relative deprivation and the stress associated with social inequality (Wilkinson, 2005).

Neither were we able to examine the distribution of public health investment in each province for a relationship between inequality and health. The public health system, including child care, maternal care, health insurance, etc., may alleviate the negative effect of income inequality on health. Some evidences in China show that the rural social benefit system favored those with more advantaged socio-economic background such as higher education, non-farm sector employment, Communist Party membership, and smaller household sizes in the 1990s, while the urban social benefits, though played a significant role in income inequality reduction, were not able to close the rising income gap driven by growing market income inequality during the period. (Gao, 2005). Therefore, it would be beneficial to policy designers if future studies could check the possible mediating effect of the public health system on health as well as other social benefits such as housing, social security, food subsidies etc. All these systems are health-related, but if the allocation are unequal and only favor the rich and the powerful, the structure of these public systems should be reconsidered.

A possible limitation of this study relates to the use of the Gini coefficients as a measure of provincial income inequality in our model. The Gini coefficient is not year-specific; but instead is a means during a 10-year-peorid (1985-1995) and 4-year-period (1989-1993). Use of the Gini coefficient of an earlier period than our study period is based on our contention that there is certain 'lag effect' in terms of income inequality on health. We choose to use Xu and Zou's income inequality result due to the fact that the CHNS data is not nationally representative and Xu and Zou's data is more reliable and comprehensive despite the fact that it only includes urban areas. For Gini ratios calculated from the CHNS data, we believe that it still provides important information in detecting the change in income and income inequality in China during the 1990s. Actually it is found that the income inequality measures for the whole CHNS sample (not provincial specific) is similar to that calculated by Ravallion and Chen (2004) using the entire NBS (National Bureau of Statistics) sample[7] (Benjamin et al., 2005), so it is unlikely that our conclusion is an artifact of the CHNS. By all

[7] The Gini coefficient increases from 0.37 to 0.44, and the 90-10 ratio rises from 6.93 in 1991 to 11.04 in 2000.

means, we find that income inequality increases the probability of reporting poor and fair health; at least for the majority of the sample. Nevertheless, the effect of income inequality is stronger when use the Gini coefficients from CHNS than from Xu and Zou's study since the former is significantly larger than the latter.

In summary, based on data from nine provinces, this study indicates that provincial-level income inequality exerts an independent effect on individual risk for poor health. There appears to be a clear contextual effect of income inequality on health status in China between 1991 and 2000. The effect could be negative before income inequality reaches a relatively high level and then reverses. Further, this association is not confined to the poor. People with higher absolute individual income suffer from societal income inequality when living in a province with higher income inequality. However, the strongest relationship between income inequality and health status is found among individuals of lower income levels, and of other disadvantaged socioeconomic status. The findings of this study are mostly consistent with many previous studies, such as those in the U.S. and Chile. They are also largely consistent with the study by Li and Zhu (2006) analyzing the effect of community level income inequality on self-reported health in China. As a country experiencing dramatic changes in income distribution amidst social and economic transitions, the example of China suggests that income inequality is an important social determinant of population health. While many developing countries are now focusing more on the absolute economic and income growth, the experience from China indicates that absolute increase in income does not necessarily guarantee the improvement of health for all.

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CHAPTER 2

CHILDREN'S HEIGHT AND ITS DETERMINANTS IN CHINA IN THE 1990S

ABSTRACT

This paper uses longitudinal data from the China Health and Nutrition Survey in the 1990s to study children's height and its socioeconomic determinants. The CHNS cohort used in this study is characterized by low height-for-age Z scores and decreased inequalities between rural and urban, and male and female children. There are also age differences through the survey years. A dynamic model which includes a lagged health term is used to model a health production function of children's height over the survey period. It is found better in finding the effect of time-varying variables than the static model, which downplays the importance of time varying variables. The results show that a group of individual, household and community factors all play important roles in determining children's height in China and the determinants differ between rural and urban areas.

2.1 Introduction

This paper analyzes Chinese children's height and its determinants in the 1990s in order to provide some insights on the effects of socio-economic development on child health after the economic reforms. China not only has the largest population but also has the largest number of children under the age of 16 in the world[8]. Child health, as a

[8] Based upon statistics in 1997 from the State Statistics Bureau, China has 315 million children at and under the age of fourteen, among which there are 210.2 million (109.7 million are males and 100.5

biological standard of living, can be a better measure of social-economic welfare during some phases of growth than per capital income (Komlos, J., 1994). Data on child health can provide useful information about the extent of social inequalities, as well as the temporal changes in the economic conditions of that society as a whole or of its sub-groups (Bielicki, 1998).

Many empirical studies have used children's height as a measure of child well-being and have proved it informative and accurate. Unlike children's weight, a short-term measure for biosocial quality of life, height reflects the cumulative life course of a child and his/her growing environment. In fact, height has been shown to be an objective measure of children's general health status and is particularly sensitive to the quality of social and economic environments (World Health Organization, 1995). Statistically, children's height during prepubescent age is common across racial and ethnic groups, and variations in height across different child populations are largely determined by variations in the socioeconomic environment in which they reside (World Health Organization, 1983). All these features make children's height a good candidate to indicate children's general health as well as to allow comparison across different demographic groups.

The paper is organized as follows. First the background of China in the 1990s is introduced and results from previous studies on children's health in this specific period are discussed. The second section introduces the data used for this study and

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million are females) children ages six to fourteen, occupying 17.01% of the total population and about one fifth of the total number of children in the world.

presents some descriptive analysis of child growth. The next section outlines the analytical framework and the methodology of the dynamic health demand model. The final two sections summarize the results and conclude.

2.2 ***Background: China in the 1990s, children's health and contribution of this study***

The 1990s provide a unique opportunity to observe the effects of social and economic influences on children's health in China. It is well known that during the past two decades, China has been developing rapidly due to the economic reforms initiated in the early 1980s. Characterized by vast achievements in gross national product (GDP), average income, and poverty reduction, the 1990s witnessed great improvement in the Chinese people's living standards. A better living environment provides the material base for the improvement of children's physical development. Due to the birth control policy, the fact that most urban households have only one child and rural families no more than two also creates favorable external conditions for the development of Chinese children. Evidences show that the physical status of children has improved during the 1990s (Sun, 2003; Wang and Ye, 2005). According to a Government White Paper[9], in 1994, the mortality rate of children under five in all developing countries averaged 101 per thousand; that in East Asia and the Pacific region, 56 per thousand; and in China, only 43 per thousand. The nutritional status of Chinese children has also gradually improved since the supplementary food program was developed in the 1980s and since breastfeeding was advocated in the 1990s. Between the period of 1980 and 1994, 35 percent of children in developing countries experienced low weight, while 23

[9] The Situation of Children in China, Government White Paper, 2004/05/20.

percent of children in East Asia and the Pacific region, and 17 percent of children in China had low weight[10]. In short, due to the economic and social development, children's health has experienced changes since the economic reforms. It is of policy importance to know what socioeconomic factors have influenced children's health during the period of economic reforms initiated in the early 1980s since improvement in nutritional and health status of children will have important payoff in the long-term.

The contributions of this study are summarized as follows.

First, this study is to bridge the research gap of understanding Chinese children's health. So far, most of the existing literature is largely description of child health, the published studies on child health and its determinants in China are rather limited. A lot of research interest has focused on women's reproductive health, the one-child family planning policy, socioeconomic effects of population growth, and fertility transition, but very few have focused on children's health. This is mainly due to two reasons. One is that the one-child family planning policy has attracted most of the attention as it is very controversial and has a huge impact on the society. The other reason is that a lot of Chinese datasets are generally not accessible to foreign scholars and therefore very little research about child health in China has been conducted outside China (Maitra et al., 2006). One important aim of the present paper is to bridge that research gap and to explore strategies for improving child health.

[10] The 1996 State of the World's Children Report of the United Nations.

Second, this study will be the first to explore the different determinants in rural and urban areas, respectively. Despite the overall economic and human development, the reforms have also created greater levels of inequalities among different demographic groups, particularly between rural and urban populations. Children are not an exception. It has been shown that rural children, who make up the majority of Chinese children (more than 65%), grow much less overall than their urban counterparts. Studies by Shen et al. (1996) and Sun (2003) have shown that between 1987 and 1992, the net increase of height for rural children was only one fifth of that for urban children (0.5cm vs 2.5cm) and the stunting rate of children was 38% in rural areas compared to 10% in urban areas in 1990. The widened differences in physical growth between rural and urban children are most probably related to a more inequitable distribution of the economic resources for nutrition and health in rural and urban areas (Shen et al., 1996).

Third, among the few studies of children's health in China, researchers mostly use BMI, infant survival, self-reported health and nutritional intakes as a measure for child health. For example, Grigoriou et al. (2005) find that income has a positive impact on infant survival in China. Li et al. (1999) suggest that chronic socioeconomic underdevelopment and genetic effects are more likely to lead to Chinese children's malnutrition. Maitra et al. (2006) find that parental education indirectly influences child health, measured by mother's report of child's health status. This study will be one of the first to systematically examining the socio-economic determinants of Chinese children's height as understanding children's health and its determinants is important not only because its impact on a child's welfare, but also because of its persistent impact on the child's future development and productivity as an adult.

Finally, this paper contributes to the existing literature on health of Chinese children by using panel data to model children's height. Children's height is a result continually affected by nutritional intakes and other variables and would be better modelled in a dynamic setting. None of the previous studies utilize any longitudinal data, mostly because such data rarely exists or would be too expensive to get. The China Health and Nutrition Survey (CHNS) data used in this study became publicly available in the 1990s. It not only contains information about individual, household, and community, but also covers 5 waves of observations for the same child in the 1990s. Instead of using cross-sectional data and models a dependent variable that summarizes the history of intakes by realization of independent variables in specific time intervals, it is possible to use the CHNS data to observe the dynamic interrelationship between current and past measurement of health and their dependence on time varying explanatory variables for the Chinese children. Therefore, this study will be the first to systematically measure both of the time-invariant and time-varying socio-economic determinants of Chinese children's height in the 1990s using five waves of data from the China Health and Nutrition Survey. The hypothesis is to look at whether certain household characteristics, such as parent's education and household income, and community characteristics, such as community road conditions and prices of food, are important in determining children's health in China.

2.3 Data

The China Health and Nutrition Survey data is used for this study. It includes information about 4400 households with a total of 16,000 individuals from over 5 waves of survey years, namely, 1989, 1991, 1993, 1997, and 2000. The data is collaboratively collected by the Carolina Population Centre at the University of North Carolina at Chapel Hill, the Chinese National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. A multistage random cluster process is used to collect the data from nine provinces that vary considerably in geographic locations, economic development, public resources, and health indicators. Though the CNHS data are not designed to be representative of the whole Chinese population, they are believed to provide a sufficient range of values for a large enough sample to correctly model and estimate general behavioural relationships in China during the survey years (Henderson, 1997). Detailed information on health and nutrition was collected at the household level and individual level. CHNS also makes available a carefully constructed income variable for each household that includes wage income, non-wage income, farming income, dividends and various subsidies. In addition, community data was collected with respect to food markets, health facilities, family planning officials, and other social services and community leaders.

The richness of the longitudinal CHNS data set allows me to examine children's health in two important ways. First, it provides information of an important measure of children's health, height, in 5 continuous waves. Previous studies have suggested that using longitudinal data to analyze inter-temporal connections between children's height and its determinants have advantages over cross-sectional data (Cebu Study Team, 1992; Bhargava, 1994; Hoddinott and Kinsay, 2001; Fedorov and Sahn, 2005). This is because longitudinal analysis can help understand the change in children's health over time and the related determinants that can explain the change. Second, there is very detailed information on important exogenous and endogenous variables in the data set. It includes all the standard socioeconomic variables found to be related to child health outcomes such as age, gender, household income, parents' education, parental heights etc. Information necessary to control for the child's environment was also collected, such as measures of water and sanitary conditions in the household. Finally, there are detailed community-level data, such as food prices and community road conditions, that both allow for controlling for explicit community-level effects and providing the information needed to create the instrumental variables necessary for the estimation procedures.

Specifically, the data on children's height is from the Nutrition and Physical Examination survey in the CHNS. The core of the study sample is a cohort of 574 children less than 7 years old at the starting period (1989) who had complete information in all five waves (1989, 1991, 1993, 1997, 2000). There is some panel attrition over the survey years, but a T test shows that no significant difference exists between those who were lost to follow-up and those who continued in the survey in terms of social-demographic characteristics and anthropometric measurements. Thus, the panel attrition is not systematic, which allows using the exiting data to generalize the results. The age distribution in the first wave (1989) of the survey is as follows: there were 72 children (12.5%) under 1 year old, 105 children (18.3%) between 1-2 years old, 108 children (18.8%) between 2-3 years old, 121 children (21.1%) between 3-4 years old, 76 children (13.2%) between 4-5 years old, 49 children (8.5%) between 5-6 years old, and 43 children (7.5 %) between 6-7 years old. The fact that there were more young children in the distribution than old age children probably reflects an increase in birth rate from 1984 (19.9%) to 1989 (23.3%) [11](China Statistics, 2005).

Since children's height varies systematically with age and gender, the Z-score for height-for-age/sex is used in the analysis. Z-score is a standardized measure of child health by comparing to a same age/sex child from a reference healthy population. It is calculated by first subtracting the mean height of the same age and sex from a child's height, and then dividing the difference by the standard deviation of the reference data for that age and sex. This study uses the US CDC growth chart population as the healthy reference[12]. Height outliers, defined as z scores (defined below) that are greater than 5 or less than -5,[13] are not found in the CHNS sample.

$$Zi = \frac{Hi - Hmean}{S.D.}$$

According to Table 2.1, although the value of the height-for-age Z-score increased significantly from 1989 (-1.44) to 2000 (-1.18), it had been consistently negative with

[11] http://www.allcountries.org/china_statistics/4_2_birth_rate_death_rate_and.html
[12] More information can be found at: http://www.cdc.gov/nccdphp/dnpa/growthcharts/sas.htm
[13] More information of outliers can be found at: http://www.cdc.gov/nccdphp/dnpa/growthcharts/resources/BIV-cutoffs.pdf

an average of -1.40 across all five waves, suggesting that the average height of Chinese children is lower than the standard height for the same age children using the 2000 CDC growth chart. The findings are similar to previous studies that find the average height-for-age of preschool children in China lower than the median of all WHO countries using the WHO standard (Shen et al, 1996; Ellen, 1996).

Table 2.1 Height for age Z score for each year in CHNS data

Survey Year	Mean	N	Std. Deviation	Minimum	Maximum
1989	-1.4487	574	1.22172	-4.33	4.22
1991	-1.5436	628	1.10428	-4.85	1.64
1993	-1.4667	662	1.10242	-4.52	2.45
1997	-1.3788	622	1.07061	-4.31	1.75
2000	-1.1874	649	1.03759	-4.28	1.73
Total	-1.4036	3135	1.11259	-4.85	4.22

Unsurprisingly, the distribution of height in the selected sample is characterized by disparities between rural and urban areas. Table 2.2 shows that the difference of the average height-for-age Z score between rural and urban areas was about 10% in 1989, 8% in 1991, 18% in 1993, 21% in 1997 and 9% in 2000. The increased disparity during the 1990s was also found in previous studies (Sun, 2003) and could be due to a faster socioeconomic improvement in the urban areas than in the rural areas.

In addition to Z score, stunting is defined as a child whose z-score for height-for-age is -2 or below, suggesting that the child's height is 2 standard deviations below the mean growth in height of a reference healthy child with the same gender and age. Stunting is considered a cumulative indicator of slow physical growth, primarily caused by repeated episodes of diarrhea, other childhood diseases, and insufficient dietary intake (WHO, 1995). Therefore, the stunting rate of a population makes a good indicator of the general health of the population. According to Table 2.2, totally 30% of the children are stunted in the studied sample, with an increase from 1989 (32%) to 1991 (35%) and decreases in 1993 (33%), 1997 (29%) and 2000 (23%). The stunting rate in the CHNS sample is significantly larger than the rate in a previous study that found that the prevalence of stunting among preschool children was only 8.9% in urban areas (Chang et al., 1996). The difference may be due to the use of different growth references in this study.

Table 2.2 Comparing rural and urban children's HAZ and stunting rate

Year	Urban/Rural	HAZ	Stunt
1989	Urban	-1.33	0.31
	Rural	-1.49	0.33
	Total	-1.45	0.32
1991	Urban	-1.45	0.28
	Rural	-1.57	0.37
	Total	-1.54	0.35
1993	Urban	-1.3	0.22
	Rural	-1.52	0.36
	Total	-1.47	0.33
1997	Urban	-1.19	0.25
	Rural	-1.44	0.3
	Total	-1.38	0.29
2000	Urban	-1.12	0.21
	Rural	-1.21	0.23
	Total	-1.19	0.23
Total	Urban	-1.28	0.25
	Rural	-1.45	0.32
	Total	-1.4	0.3

Table 2.2 also shows noticeable rural/urban differences in stunting rates with the averages in urban and rural areas are 25% and 32% consecutively. The difference of

the stunting rate between rural and urban children shows an increasing pattern from 1989 (2%) to 1991 (9%) and 1993 (14%), followed by a decreasing pattern to 1997 (5%) and 2000 (2%), indicating that in the 1990s there were significant health difference between rural and urban children. The difference in 2000 decreasing to a slight 2% indicates that there has been a growth catch-up among the rural child population.

Table 2.3 Comparing male/female children's HAZ and stunting rate

Year	GENDER	HAZ	Stunt
1989	Male	-1.43	0.32
	Female	-1.47	0.33
	Total	-1.45	0.32
1991	Male	-1.48	0.33
	Female	-1.62	0.37
	Total	-1.54	0.35
1993	Male	-1.43	0.31
	Female	-1.51	0.35
	Total	-1.47	0.33
1997	Male	-1.38	0.3
	Female	-1.38	0.27
	Total	-1.38	0.29
2000	Male	-1.19	0.24
	Female	-1.18	0.21
	Total	-1.19	0.23
Total	Male	-1.38	0.3
	Female	-1.43	0.31
	Total	-1.4	0.3

Similar disparity can be found between genders. Table 2.3 shows that the mean height for age Z-score is -1.38 for male and -1.43 for female. Over the five survey periods, the improvement for female height is on average greater than that for male, showing there is a decreased gender disparity in children’s height. The stunting rate in Table 2.3 also shows an improved female status over the survey period with females having higher stunting rates than males in the early 1990s (1989, 1991 and 1993), followed by lower stunting rates than males in 1997 and 2000. The decreased gender disparity in the studied sample is clear evidence for a female buffering in China during the survey years. Further, the decreasing stunting rate among female children also suggests an evident height catch-up among females. This finding corresponds to the literature (Malina et al. 1985; Bogin, 1989; Crooks, 1994; Eme, R. F. and Kavanaugh, L., 1995), which suggests that female children are more 'buffered' than male children in disadvantaged socioeconomic situations. Bogin et al. (1989) suggest female buffering may account for the greater sensitivity of boys to environmental conditions than girls. Eme & Kavanagh (1995) suggest a biological link between gender and susceptibility to psychological stress where boys were found to be more seriously affected by stress than girls. All in all, the hypothesis of female buffering is interesting, and has been proposed by a number of researchers. Continued research with older children is needed to sort out this relationship.

In addition to residential and gender disparities, there is also an age difference in children's height-for-age Z scores in the CHNS sample. Figure 2.1 shows a decrease in Height-for-age Z score with age and accordingly, an increase in stunting rate from birth to about 2 years old, after which the average height-for-age Z scores and stunting rates remain relatively constant. Such an age trend of stunting rate is consistent with the findings of a large body of empirical studies that showed most growth failure occurs from before birth until two to three years of age (ACC/SCN, 2000). In other words, once a childs health is damaged at a young age, it is hard to catch up in the future.

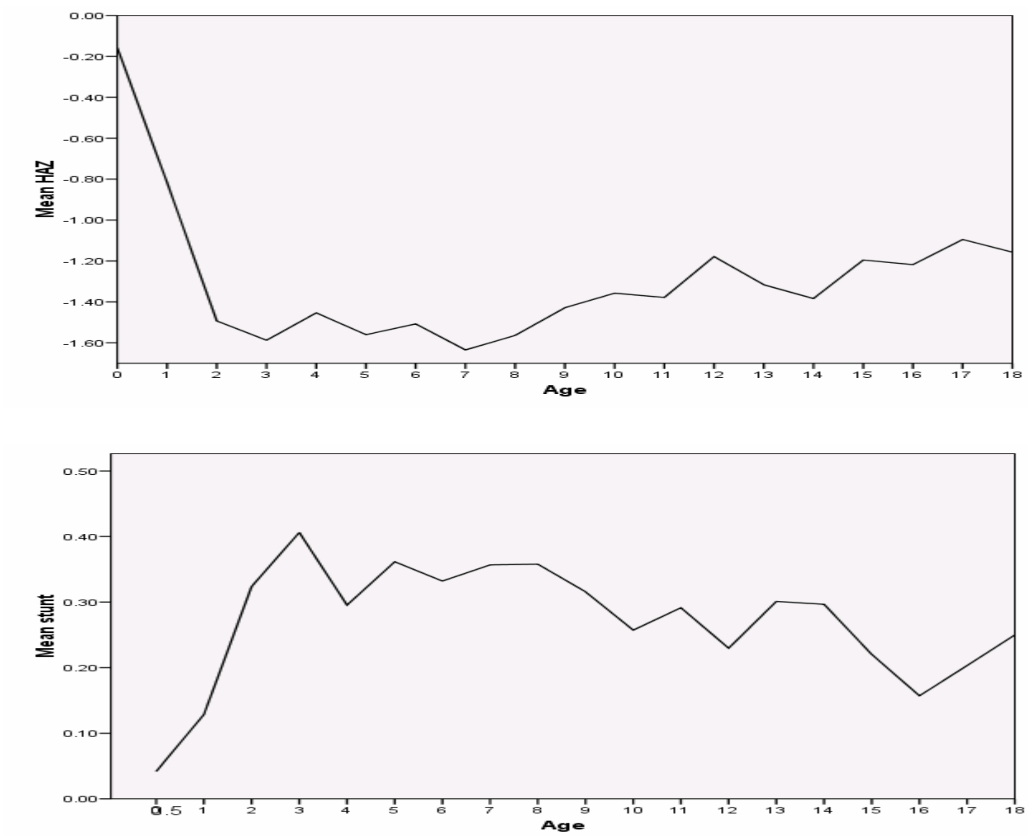

Figure 2.1 Mean HAZ and Stunting ratios among different age groups

In sum, the CHNS cohort used in this study is characterized by low height-for-age Z scores and decreased inequalities between rural/urban, male/female and difference age populations through the survey years.

2.4 Analytic framework

After the previous descriptive analysis of the data, a health production function is used to further estimate the determinants of a child's health. The theoretical model follows the earlier works of the Cebu study Team (1991) in the Philippines, Strauss and Thomas's (1995) study in Brazil, Glewwe, Koch and Nguyen's (2002) study in Vietnam and Fedorove and Sahn (2005)'s study in Russia. Without loss of generality, a child's health status (H) can be written as a function of health inputs (HI), the health environment (E), and the genetic health endowment (G).

$$H=h(HI, E, G) \tag{1}$$

It is then taken into the household utility maximization function which includes household consumption (C), children's health (H) and leisure (L).

$$U= u(C, H, L) \tag{2}$$

The household is constrained by the household's financial budget where the total spending on non-health related consumption (Pc*C) and health-related consumption (Ph*HI) cannot exceed total earnings w*(T-L) and wealth (a). T is total time budget, which includes leisure L and working time (T-L). w is wage rate.

$$Pc*C+Ph*HI=w(T-L)+a \tag{3}$$

A household maximizes its utility (2) subject to its time and financial budgets (3) and derives the optimal amount of health input in each time period. This optimal amount of input can then be taken back into the health production function and a reduced form arises where a child's health is a function of health inputs, environment, income, prices and other exogenous socio-economic variables. In order to treat height as a capital stock, which depends on past values as well as current inputs (Grossman, 1972), a lagged health (previous health) is added on the right hand side of the reduce form (see Equation 4). The lagged health term is considered a sufficient statistic for all past inputs and therefore carries on the impacts of all previous exogenous variables (Cebu Study Team, 1991).

$$H_t = f(H_{t-1}, P_c, P_m, N_t, Y_t, E_t, G, e_t), \qquad (4)$$

Equation (4) shows current health (H_t) as a function of previous health (H_{t-1}), prices of consumption goods (P_c), prices of health inputs (P_m), time endowments (N_t), household income (Y_t), exogenous environmental characteristics (E_t), and genetic endowment (G). The subscript t specifies the time period.

Model specifications are discussed below. A descriptive summary of all the variables are presented in Table 2.4. The dependent variable is the child's height-for-age/sex Z-score, which allows comparison among all children. The average Z score is -1.4, suggesting the CHNS sample is on average shorter than the reference sample. Independent variables include children's own characteristics, household and community characteristics that influence how well energy and nutrient needs for growth are met. Child's age and age squared are both included since growth velocity might not be constant for all ages, and may change with age in a curvilinear fashion. The average age in the sample is 8 years old. Child's status tells whether he/she is the only child in the household, which indicates a favorable household environment. 61% of the sample is the only child in the household, which is probably due to the One-Child Policy. Heights of parents are indicators for genetic endowments and reflections of parents' nutritional history. Parental education is considered separately as they might influence child health differently (Barrera, 1990). On average, father's education is higher than mother's education. Mother's age is included as it presumably affects her experience with child caring. Residential affiliation shows whether the household lives in rural or urban areas since there are significant differences between these two regions. Average yearly per capita income in the household is 1270 yuan (about US$158) in the studied sample. Household water and sanitation condition presumably affect the child's hygienic environment. The water measurement runs from highest quality to lowest quality, that is, from tap water in the household (value=1) to tap water in the courtyard (value=2) to pressurized well in the courtyard (value=3) to water from other places (value=4). The average value of water is 2.27, suggesting that not all the households have easily accessible tap water. Community characteristics that might affect the child's living condition include community road condition, which is used as a proxy for the quality of other public services in the community. Road condition runs from low quality to high quality, that is, from dirt (value=1) to stone (value=2) to gravel or mix (value=3) to paved (value=4). The average road condition is 2.16 suggesting the public road condition is rather low on average. Community characteristics also include prices of food in the local market. Three most common items are included, rice, most popular vegetables and pork, all of which are supposed to be important and accessible sources of nutrients for child health. Descriptive statistics for the variables in the studies sample are presented in Table 2.4.

Table 2.4 Descriptive statistics of all variables

Variable	Mean value
Height for age Z score	-1.40
Age	8.12
One child %	61
Female %	44
Mom's height	154.20
Dad's height	165.01
Mom's education	15.50(less than 6 years' primary education)
Dad's education	19.60(More than 6 years' primary education)
Mom's age	31.45
Rural %	75
Water	2.27
Roads	2.16
Price of rice/kg	0.91
Price of veg/kg	0.45
Price of pork/kg	5.18
Per capita income/year	1270.47

N=3135.
Prices and income are in RMB value.

Y is represented by per capita household income. Though previous studies have shown that expenditure data are more accurate than income data (Deaton, 1997; Townsend, 1994), there is no expenditure or consumption data available in the CHNS data. Therefore used in this study is the income data, which is carefully constructed by summing up all possible income sources in the household including wage income, non-wage income, farming income and subsidies, etc. One problem with Y arises when household income might be correlated with the error term of the health function derived in equation (4). For example, a household with a severely stunted child may respond to the child's health situation by working longer and making more income so that they can spend more on health inputs such as food and medical services. If so, any positive effect of household income will be underestimated with the endogeneity problem described above. One way to address the endogeneity of per capita income is to impose additional orthogonality conditions to control for income using identifying variables, such as residential location, household composition, education of parents, household assets and non-labor income. In this study, residential location (rural/urban), household size, and education of household head are used for controlling for household income.

Another endogeneity problem arises from the correlation of the error term (r_t) and the lagged health (H_{t-1}) on the right-hand-side of the reduced form. This study follows Arellano and Bover (1995), Ahn and Schmit (1995), Blundell and Bond (1998), who suggest using the lags of the regressors together with the lagged first differences of the dependent variables as instruments for the lagged dependent variable given enough regressors that are uncorrelated with individual fixed effects. Their dynamic panel estimators are designed for situations similar to this study, they are: (1) "small T and large N" panels; (2) a linear functional form; (3) a single left-hand-side variable that is dynamic and depending on its own past realizations; (4) independent variables that are not strictly exogenous and possibly related with past realization of the error; and (5) fixed individual effects. They argued that their estimators are consistent on all explanatory variables. Using the generalized method of moments (GMM), the Arellano-Bover/Blundell-Bond estimator can be calculated by the dynamic panel-data model that allows past realizations of the dependent variable to affect its current level.

Therefore, in this study, all time-varying variables' past values (including age, household income, household water condition, community road condition, and community food prices) and the lagged first differences of height are used as instruments for the lagged height in the left hand side of the equation (4). The STATA command "xtabond2"[14] (Roodman, 2007) is used to estimate the dynamic panel data model using system GMM together with the Windmeijer (2005) finite-sample correction to the reported standard errors in a two-step estimation. An Arellano-Bond's autocorrelation test is also performed in the command since it is important when lags are used as instruments in a model.

2.5 Results

Table 2.5 presents a "naïve" regression using Ordinary Least Squares. The dependent variable is Height-for-age Z score (HAZ), and independent variables are all the explanatory variables except the lagged HAZ. According to the result in Table 2.5, being one child, genetic endowment (parents' height), mother's education and age all significant increase a child's Height-for-age Z score. Household improvements in water conditions and per capita income also positively affect child's height. So is community improvement in road condition. Although the naïve regression ignores the individual-specific effects and assumes that the error term is random and normally distributed with zero mean, it does provide some instincts of the possible important household and community determinants of children's height.

[14] More information about "xtabond2" can be found at http://ideas.repec.org/p/boc/asug06/8.html.

Table 2.5 OLS estimates of all explanatory variables

Variable	Coefficient	SE	
Age	-0.045	0.041	
Age^2	0.002	0.002	
Female	0.037	0.045	
One child	0.138	0.047	***
Mom's height	0.055	0.005	***
Dad's height	0.047	0.004	***
Mom's education	0.005	0.003	*
Dad's education	0.001	0.004	
Mom's age	0.018	0.003	**
Rural	-0.054	0.058	
Water	-0.065	0.024	***
Roads	0.120	0.030	***
Log price of rice	-0.019	0.015	
Log price of veg	-0.002	0.030	
Log price of pork	0.001	0.004	
log per capita income	0.051	0.030	*
Constant	-18.430	0.931	

N=2592; T=5 (1989-2000). SEs are robust to cluster effects at the community level.
* significant at 10%
** significant at 5%
*** significant at 1%

Table 2.6 presents the GMM estimates of equation (4), using the dynamic model, where the same children over all five survey periods are included. In all estimates the dependent variable is the child’s height for age Z-score. Significant predictors include children’s past height-for-age Z score, mother’s height, father’s height, mother’s age, community road condition, price of the most popular vegetable and per capita income. Age, gender, being the only child in the household, residential affiliation, parents’ education, ways to get water and prices of rice and pork are found not significant. It seems that children’s individual characteristics (age, gender, being the only child) do not matter in the above estimation except their height in the earlier period. Among household characteristics, parents' height is significantly related with child's height, implying that genetic endowment is important for children's height; mother's age, representing her experience of taking care of children, and per capita income, are also significant variables, indicating that parents' situation and household environment are important for children's growth. Community characteristics such as road conditions and prices of vegetables also have significant effects on children's height, illustrating the importance of community factors. Parents' education is not find to be significant for child height, which is different from many previous studies. A possible explanation is that the majority of the sample has very similar education status and therefore does not vary as much as children's height changes. Another reason could be that education would not necessarily improve a child health if there is a lack of health education as part of total education. A recent report[15] of how China is lack of a public health education may somewhat explain the insignificant effects of parental education on child health in this study.

[15]A report titled *China: Public Health Education Sorely Missing* argues that "…poor knowledge about epidemics and infectious diseases, and a lack of government effort to educate the public about prevention, are now threatening to undo some of the progress that China has made in cutting poverty and boosting incomes over the past 25 years." The report can be accessed at : http://ipsnews.net/news.asp?idnews=37728

Table 2.6 GMM estimates of all explanatory variables

Variable	Coefficient	SE	
HAZ (t-1)	0.201	0.075	***
Age	-0.120	0.293	
Age^2	0.004	0.010	
One child	0.050	0.075	
Female	0.049	0.069	
Mom's height	0.051	0.008	***
Dad's height	0.042	0.008	***
Mom's education	0.001	0.004	
Dad's education	-0.006	0.004	
Mom's age	0.009	0.005	*
Rural	-0.120	0.092	
Water	0.028	0.037	
Roads	0.093	0.048	**
Log price of rice	-0.041	0.115	
Log price of veg	-0.100	0.060	*
Log price of pork	0.030	0.111	
Log per capita income	0.085	0.047	*
Constant	-15.807	3.063	

N=519; T=5 (1989-2000). SEs are robust to cluster effects at the community level.
* significant at 10%
** significant at 5%
*** significant at 1%

The estimation procedure is also separated for the urban and rural sample, respectively. As is shown in the previous section, both height-for-age z-score and stunting ratios differ widely between rural and urban samples. The statistical tests also show that the coefficients for the two samples differ significantly. The test involves estimating the results for the urban and rural samples, first separately then pooled, and performing a likelihood ratio test of the null hypothesis of no difference between the samples.

Table 2.7 GMM estimates of the dynamic health demand function for rural and urban samples separately

	Rural			Urban		
Variable	Coefficient	SE		Coefficient	SE	
HAZ (t-1)	0.306	0.097	***	0.273	0.096	***
Age	0.133	0.348		-1.243	0.502	**
Age^2	-0.004	0.012		0.042	0.018	**
One child	-0.092	0.079		0.483	0.164	***
Female	0.088	0.076		0.050	0.112	
Mom's height	0.040	0.009	***	0.057	0.015	***
Dad's height	0.028	0.009	***	0.076	0.012	***
Mom's education	-0.002	0.004		-0.009	0.011	
Dad's education	-0.006	0.007		-0.011	0.007	
Mom's age	-0.0004	0.006		0.015	0.009	*
Water	0.083	0.040	**	-0.192	0.069	***
Roads	0.063	0.051		-0.076	0.096	
Log price of rice	-0.020	0.126		-1.750	0.645	***
Log price of veg	-0.131	0.063	**	-0.001	0.120	
Log price of pork	0.550	0.206	***	-0.314	0.146	**
Log per capita income	0.075	0.054		-0.122	0.085	
Constant	-14.360	3.790		-11.920	4.490	

Table 2.7 reports the separate estimations for the rural sample and the urban sample. One important distinction between the two samples is that age, age-squared and being one child in the family and mother's age are significant for urban children, but remain insignificant for rural children. Income and road conditions become insignificant once the sample is separated, but interestingly, the effects of income and road conditions are different in the two samples, albeit insignificant. Household access to water becomes significant for both the rural and urban samples, albeit the effects are in different direction, with rural children's height increases with deteriorating water condition and urban children's height increases with improvement in water condition. Similarly, the

effect of the price of pork also differs in the two residential areas with rural children's heights increase and urban children's heights decrease with rising pork price.

In sum, while the dynamic model suggests several important determinants of children's height in China, it also shows that there are significant differences between rural and urban areas. As genetic endowment is significant for both rural and urban children's heights, children's age, children's status as the single child in the family and mother's age are more important for urban children than rural children. Household income and road conditions becoming insignificant in the two sub-samples may reflect that there are significant difference between rural and urban areas in terms of household income and road conditions, which renders them significant in the pooled sample but insignificant in the separate sample. Household access to water and price of pork have different effect on children's health in the two sub-samples may warrant future study. Parents' education is not significant, which is different from many other studies. Community level data is important in the sense that road conditions and prices of basic food all have significant effect on children's health.

Comparatively, a static model is estimated with omitted lagged height. It assumes a random-effects error structure using all five waves of observations. Therefore it estimates a static relationship between children's height and all the determinants in equation (4) except $H_{(t-1)}$. The results in Table 2.8 shows that time-invariant variables becomes more important in the static model than in the dynamic model, such as children's age, one-child status, living in rural areas. The importance of time-variant variables decreases in the static model as per capita income and prices of basic food all become insignificant. The difference between the static model and dynamic model is due to the inclusion of the lagged height in the dynamic model, which incorporates some of the impacts of time-invariant variables and thus renders their impact smaller. Time-varying variables capture mostly effects of contemporaneous inputs into health and thus the magnitude of their impacts is higher in the dynamic model. The differences in Table 2.6 and Table 2.8 suggest that the static model tends to downplay the importance of time-varying variables, such as community road conditions, household income and food prices, all of which are of important policy values. Therefore, a dynamic model is better in finding the time-varying determinants of children's health.

Table 2.8 Random Effects estimates of a static health demand function

Variable	Coefficient	SE	
Age	-0.075	0.014	***
Age^2	0.005	0.001	***
One child	0.190	0.062	**
Female	0.100	0.063	
Mom's height	0.050	0.006	***
Dad's height	0.050	0.006	***
Mom's education	0.005	0.004	
Dad's education	0.003	0.005	
Mom's age	0.017	0.004	***
Rural	-0.128	0.078	*
Water	-0.031	0.019	*
Roads	0.038	0.020	*
Log price of rice	-0.054	0.036	
Log price of veg	0.003	0.024	
Log price of pork	0.056	0.043	
Log per capita income	0.021	0.020	
Constant	-17.830	1.230	

N=2592; T=5 (1989-2000). SEs are robust to cluster effects at the community level.

* significant at 10% ** significant at 5% *** significant at 1%

2.6 Discussion

This study explores possible individual, household and community determinants of Chinese children's health, measured by children's height for age Z score. It finds that while genetic endowments, such as parents' height, are important determinants of children's height, there are other important household and community characteristics that may significant affect children's height. Among these significant variables, mother's age, household per capita income, community road condition and price of vegetables all have impacts on children's health. Comparing with other cross-sectional studies, this study emphasizes the importance of past health as well as other time-varying variables such as income and community development.

At the same time, this study also finds differences in determinants of heights among rural and urban children. For urban children, their age, their status as a single child in the household, parents' height, household access to water, community road condition and prices of rice and pork all significantly relate to their health status. For rural children, it is their parent's height, household access to water and prices of vegetables and pork that are more important in determining their health. In addition, the effects of access to water, price of pork and per capita income all have opposite influences on rural and urban children, which remind policy makers the importance of designing different policies to address children's health in different regions.

A dynamic model is compared with a static model in the sense that a lagged health term is included in the former and omitted in the latter. A lagged health term is supposed to catch the important information of all the past influence of all the determinants of health and therefore, better explain the variations of height, as a cumulative health status, among different children. The results in this study suggests that a dynamic model is better in finding the effect of time-varying variables such as income, community road conditions etc, than the static model, which downplays the importance of time varying variables and over-emphasizes the importance of time-invariant variables.

In addition, the coefficient on the lagged height is 0.20 at a significant level, suggesting that lagged height is an important determinant of current height, and the magnitude of catch up is quite big. The relationship between current height and height in the previous period is often referred in the literature as the "catch-up effect". If the coefficient on the lagged height is 0, which means the lagged height has no influence on current height, then children who were stunted before would not experience stunting in the current stage and therefore experience a total "catch-up". The closer the coefficient is to zero, the more a stunted child tends to catch up. Compared to numerous previous studies, where the coefficients between current height and past height ranges from 21.6% in Russia to 56% in Zimbabwe and to 75% in Guatemala, the magnitude of the catch-up effect among the Chinese children in the studied sample is the biggest. Therefore, there has been a significant catch-up effect among children's height in the CHNS sample over the survey years. This is most probably due to the low value of children's height in the CHNS sample, which makes it easier to catch up.

The effect of household income implies an interesting story. Income is found insignificant in the separate urban and rural samples. But when the total sample is used, income becomes significant. The explanation may lie in the fact that there is more income difference between rural and urban areas than within each area. In other words, the rural/urban between-difference is wider enough to reflect changes in children's height, while the within-difference is not. Therefore income does matter when all children are considered. But within rural and urban areas, other household and community variables are more important than income. The different impacts of the socioeconomic determinants between rural and urban areas suggest that future economic reforms in China should pay more attention to a more equitable distribution of development resources in all regions and advocating more equitable development policies. The rural populations, particularly the rural child populations, deserve more policy attention to mitigate the potentially negative effect of the economic reforms on nutrition and health in the long term. There should be a focus on continuously monitoring of children's health so that timely information can be provided to national policy makers. More studies are needed in this area.

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CHAPTER 3

UNDER-NUTRITION AND INTRA-HOUSEHOLD INEQUALITY IN CHINA IN THE 1990S

Abstract

This paper investigates under-nutrition and intra-household inequality, and estimates the relationship between under-nutrition and intra-household inequality using the China Health and Nutrition Survey data in the 1990s. We find large scale under-nutrition in the CHNS data from 1991 to 2000 using calorie intake. Nutritional inequalities are found among various demographic groups. Intra-household inequality is also found in the CHNS data using individual level data. A U-shape relationship stands between intra-household inequality and average household nutritional well being, which has important policy application. We also discuss possible targeting strategies with a focus on upper-age-limit targeting. The uses of individual level data and household level data are compared and the former is found to better address the interested questions we ask.

3.1 Summary

During the past 10 years, many studies have examined the nutritional status of the Chinese population. A significant amount of literature has contributed to the understanding of the nutritional transition in China finding that the Chinese diet is changing into an undesirable one and obesity has become a health problem in contemporary China. Comparatively, under-nutrition has been given inappropriately less attention. Using the China Health and Nutrition Survey data from four waves during the 1990s, this paper discusses the under-nutritional status of the Chinese population and argues that under-nutrition, rather than over-nutrition, remains a bigger challenge.

At the same time, limited attention has been given to intra-household inequality in China. It is now widely recognized that inferring individual well-being from household average could be misleading because of neglecting intra-household inequality (Rogers and Schlossman, 1990). Therefore, we explore intra-household inequality in China using individual nutrition intake information from the China Health and Nutrition Survey. Our results show that intra-household inequality not only exists in Chinese households, but also varies among different subgroups, both of which are of critical policy relevance.

The paper is organized as follows: first an introduction of the nutritional status of the Chinese population is presented together with a discussion of the lack of under-nutrition and intra-household inequality analysis in this area. Data and methods are introduced in the second section. In the next two sections, nutritional status is analyzed using poverty and inequality measures established in the economics literature. Intra-household inequality is emphasized and different demographic groups compared. Next we explore possible relationship between intra-household inequality and average nutrition status with a search for a nutrition Kuznets curve. Following the analysis, we suggest possible targeting strategies within the Chinese setting with a focus on upper age limit targeting. Finally, the differences between results from individual data and from household data are discussed using analysis from the previous sections. The final section concludes the main points of this paper.

3.2 Introduction

The nutritional status of the Chinese population has been studied a great deal in recent years. A nutritional transition has been proposed in the sense that over-nutrition and under-nutrition exist side by side in contemporary China (Popkin et al., 1993, 1995, 2001, 2003; Ge et al., 1996; Doak et al., 2000; Du et al., 2002; Wu, et al., 2005). In particular, many researchers have discussed the detrimental effects of income on nutrition as the Chinese diet is shifting toward higher fat and lower carbohydrate content with increases in income. Under-nutrition, though still remains a big challenge in this fast-developing country, has received proportionally less attention compared with the vast volume of literature contributed to obesity or over-nourishment and the undesirable diet shift during the last ten years.

Among the studies that identify under-nutrition in China, most of them use Body Mass Index (BMI) or other anthropometric measures to represent nutritional status. For example, Popkin et al. (1995) found increases in both obesity and under-nutrition in China using China Health and Nutrition Survey (CHNS) in 1989 and 1991, with increases in underweight particularly evident among lower-income populations. Du et al. (2002) found that using BMI, there were around 7-8% of population who face chronic under-nutrition, defined as BMI less than 18.5, with a decreasing rate of 0.2% yearly between 1992 and 1997. A national investigation carried out in 1995 indicates that the malnutrition rate, using BMI, is 22.50% for male children at the age of seven and 40.77% for female children at the age of fourteen (Sun, 2003). Instead of BMI, this study uses calorie intake as a measure of under-nutrition as we think it is a more direct and sensitive measure than anthropometric measures (such as BMI, height and weight) as the latter is usually a cumulative consequence of the former.

Nutritional inequalities have also been previously identified. For example, nutritional differences between rural and urban populations have been identified[16] in several studies (Qu et al, 2000; Du et al., 2001). Intra-household inequality, on the other hand, has been discussed much less. It is now widely recognized that inferring individual well-being from household average could be misleading if there is intra-household inequality. Among the few intra-household studies, one study using BMI information from CHNS 1993 shows that 23% of the households with an underweight member also had an overweight member (Doak et al., 2000). Another study finds a bargaining model within Chinese households may explain food allocation along gender lines (Zhao, 1992). A third study, by Luo et al.(2001), analyzed food distribution within the household using both a discrepancy score and a ratio of food share to energy share. They found age, gender and occupational differences existing inside of the household. All these studies have identified important inequality issues within the household, but none has investigated how intra-household inequality changes with average household nutritional wellbeing. Our study focuses on both under-nutrition and intra-household inequalities in the Chinese households and explores the possible relationship between the two. The policy relevance of this is also discussed. As Rogers suggested, 'an understanding of the intra-household allocation of resources and responsibilities is essential to predict the consequences of policy decisions and the impact of development projects (Roger, 1983).

China has experienced fundamental changes after the economic reform initiated in early 1980s. The transition from socialism to a market economy transferred the

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[16] For example, using Body Mass Index, Du et al. found that the proportion of malnutrition in Chinese adults was 11.6% in 1982 and 9.0% in 1992 for urban areas, and 12.9% and 8.0% or rural areas. (Du et al., 2001)

responsibility of economic success or failure from the collective to the household. Under such circumstances, inequality inside the households could be a complex resource allocation process affected not only by individual characteristics and household power relations, but also by non-household social and economic institutions induced by the economic reform.

One important social institution that might have had an impact on the intra-household resource allocation is the One Child Policy initiated in late 1970s in China. With only one precious child in the household, limited resources within the household could primarily go to the child, who is established as the main focus of the family. Since parental decisions are usually determined by the social and economic structure of a society, their investments in their children will be in support of those decisions (Levine, 1974). The Chinese media has documented how these "little emperors" and "little empresses" are spoiled by their parents and grandparents who lavish attention and resources on their one child. It is no wonder that despite the fact that the Chinese population in general has been experiencing deteriorating access to health care, Adams and Hannum (2005) found that children's social welfare, in terms of access to health insurance, did not decline in the 1990s.

On the other hand, according to the Confucius tradition, the elderly[17] are the most important people in the family and redeem all the respect and care from their children. In recent times, the lack of a well-structured social welfare system puts the responsibility of taking care of the elderly, particularly in rural areas, on the shoulder of their adult children. But the economic reform in the past 20 years might have

[17] The elderly, in particular, is a group that entails attention as China is approaching an aging society with every one out of 10 people is over 60 years old(National Bureau of Statistics, 2006)

changed people's beliefs and attitudes towards parents and children, given the high cost of both. Which household member is more favored in such circumstances? An analysis of intra-household inequality will enable us to understand the social status of both the children and the elderly in the Chinese households during the economic reform.

Cultural factors might also have an influence on intra-household inequality. For example, if there is a son-preference in household resource allocation, then males would tend to be in an advantageous position compared to females. Historically, the Chinese emphasize the importance of investing in their sons, in order to assure familial propagation, security for the elderly, and labor provision. In fact, the imbalanced sex ratio (111.3 in 1990 according to the fourth national census) has already shown a son preference in China as people selectively give birth to boys over girls. Empirical studies have also shown that in many Asian countries, including China, there is an occurrence of female deprivation (Grewal et al., 1973; Zhao, 1992). An analysis of intra-household inequality will be able to look at the gender issue from a different angle.

In short, the period of economic reform in China in the 1990s provides a unique opportunity for this study. We think our study will shed light on intra-household inequality in contemporary China and provide useful policy suggestions.

3.3 Data and Method

Data

The China Health and Nutrition Survey (CHNS) data is used for this study. The CHNS contains information about 4400 households and 16,000 individuals collected over 5 waves: 1989, 1991, 1993, 1997, and 2000. Detailed information on health and nutrition was collected at the household level and individual level. In addition, community data was collected with respect to food markets, health facilities, family planning officials, and other social services and community leaders. The gathering of the data is collaboration between the Carolina Population Center at the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. A multistage random cluster process was used in collecting data from nine provinces that vary considerably in geographic location, economic development, public resources, and health indicators. Though the CNHS data are not designed to be representative of the whole Chinese population, they are believed to provide a sufficient range of values for a large enough sample to correctly model and estimate general behavioral relationships in China during the survey years (Henderson, 1997).

Data are pooled from 1991 to 2000 in our study. In total, the sample includes 24,010 individual observations from 5,571 households in China from the last 4 waves of the survey. Data in 1989 is omitted because the age composition in the 1989 survey is incomplete as there was no information collected for adolescents, who are an important age group in the present study.

Measurement of energy intake

While acknowledging the importance of BMI and other anthropometric measures, we use calorie intake as a measure of nutritional status, and in particular calorie adequacy, to identify those who do not intake enough according to their needs. Unlike BMI, height and weight, all of which are cumulative measures of one's nutritional status, calorie intake instantly and directly reflects one's nutritional situation and relative status in the household. In fact, inadequate BMI, height and/or weight can be considered consequences of inadequate calorie intake so they are measures of chronic under-nutrition, and acute under-nutrition.

The CHNS data collects individual's daily food intake information for each household in the survey. Interviewers paid each household a visit on three consecutive days to ask about food eaten in those days. Each household member was individually interviewed and was asked about food type and amount they consumed on each day. Preparation method and meal location were also recorded.

Using the Chinese Food Composition Tables (FCTs)18, each individual's daily food intake is converted into calorie units. The FCTs provide conversion values for over 1500 food items consumed in China, enabling a good degree of precision in calculating calorie intake values. After summing up all the calories from different food, the energy intake value is then averaged over the three-day course in order to minimize intra-individual variation and measurement error (Haddad and Kanbur, 1992). Overall, the mean per household daily calorie intake is 6,727 calories and the mean per capita daily calorie intake is 1,993 calories. For each age group, the average per capita daily calorie intake is 1,816 for young children, 2,460 for children, 3,076 for adolescent, 3,630 for prime age adult and 2,845 for the elderly.

Measurement of energy requirement

We use energy requirements created for healthy people by the Food and Nutrition Board of the Institute of Medicine (US) and Health Canada (Canada). For each

[18] The FCTs are designed by the National Institute of Nutrition and Food Safety and the Chinese center for Disease Control and Prevention in Beijing, PRC.

individual, their calorie requirement is computed based on their gender, age, height, weight, physical activity level, and for female specifically, whether they are pregnant or lactating. Even though it is intended to be a reference for the US and Canadian population, this set of calorie intake requirement is so far the most scientific, comprehensive and up-to-date reference as they are created by calculating basal metabolic rates based on individual age, gender, weight, height, pregnancy and lactation status, and activity pattern (Otton, etc., 2006). There are other energy requirement formulas available, but none of them are as good for our purposes. For example, WHO has a set of calorie requirements that were designed in the 1970s, which is not recent enough to catch the food intake trend in 1990s' China. The China Nutrition Society also developed the Dietary Reference Intakes (DRIs) specifically for the Chinese population in 2000[19]. The Chinese DRIs, however, does not take into account weight and height. Neither do they consider the physical activity level for people under 18 years old or those above 80 years old. Therefore, we decide to use the calorie requirement created by the Food and Nutrition Board of the Institute of Medicine and Health Canada. We find that the energy requirement for each age/gender group is generally higher in the Chinese DRIs than in the US and Canadian DRIs and there is more under-nutrition using the Chinese formula than using the US and Canadian ones. Therefore, using the US and Canadian formula makes a more conservative approach since our results would at least not overestimate the under-nutrition in China.

Calorie adequacy

The ratio between an individual's calorie intake and his/her recommended calorie requirement is known as the calorie adequacy ratio. If an individual is taking exactly

[19] More information can be found at http://www.cnsoc.org/biao/biao1.htm.

what he/she is supposed to take according to their daily calorie requirement, their calorie adequacy is one. Therefore, anyone whose calorie adequacy is greater than 1 is taking more than what they should take and considered over-nourished. Accordingly, those whose calorie adequacy is less than one are defined as under-nourished.

Subgroups

Since our goal is to identify intra-household inequality and those groups at a disadvantage, we need to partition the sample into subgroups for comparison in the following analysis. Several categorizing strategies are applied to the CHNS sample. First, the sample is classified into different age groups, including young children (less than 5 years old), children (6-10), adolescents (11-19), prime age adults (20-55) and the elderly (above 56). In order to investigate the gender difference, the sample is divided into male and female groups. Finally, the sample is divided into one-child households, more-than-one-child households, and no-child households, in order to see the possible effect of the One Child Policy on the household allocation of food. A demographic composition of the sample is presented in Table 3.1.

As shown in Table 3.1, the average age increases from 31.5 in 1991 to 38 in 2000 and more than half of the sample is prime-aged adult. The percentage of young children and children is around 10% to 15%. The numbers of male and female are quite balanced in the sample. But there exist significant gender imbalances among different age groups in the sense that while there are slightly more females than males in the adult and elderly groups, there are significantly more males than females among the

Table 3.1 Descriptive statistics of CHNS 1991-2000

YEAR	1991			1993			1997			2000		
Variable	**N**	**%**	**Mean**	**N**	**%**	**Mean**	**N**	**%**	**Mean**	**N**	**%**	**Mean**
Age	***11778***		***31.51***	***11069***		***32.73***	***10258***		***35.66***	***10757***		***38***
young children	843	7.16%		562	5.08%		294	2.87%		269	2.50%	
children	1126	9.56%		1162	10.50%		838	8.17%		546	5.08%	
adolescents	1861	15.80%		1725	15.58%		1568	15.29%		1681	15.04%	
adults	6187	52.48%		5837	52.73%		5661	55.19%		6125	56.94%	
elderly	1767	15%		1783	16.11%		1897	18.49%		2199	20.44%	
Gender	***11778***		***0.52***	***11069***		***0.51***	***10258***		***0.51***	***10757***		***0.51***
male	5681	48.23%		5392	48.71%		5051	49.25%		5299	49.26%	
female	6097	51.77%		5677	51.29%		5207	50.76%		5458	50.74%	
Education	***11778***		***2.15***	***11069***		***2.18***	***10258***		***2.3***	***10757***		***2.4***
primary	3043	25.84%		2625	23.71%		1849	18.02%		1711	15.91%	
middle	4177	35.46%		4015	36.27%		3736	36.42%		3471	32.27%	
high	4337	36.82%		4216	38.09%		4391	42.81%		5167	48.03%	
college	221	1.88%		213	1.92%		282	2.75%		408	3.79%	
Rural affiliation			***0.69***			***0.7***			***0.65***			***0.67***
urban	3594	30.51%		3279	29.62%		3582	34.92%		3583	33.31%	
Rural	8184	69.49%		7790	70.38%		6676	65.08%		7174	66.69%	
Household Income			***4766***			***5354***			***5683***			***4993***
very low	2593	22.02%		2651	23.95%		2068	20.16%		2988	27.79%	
low	3291	27.94%		2692	24.32%		2438	23.77%		2432	22.61%	
middle	3359	28.52%		2602	23.51%		2538	24.74%		2625	24.40%	
high	2232	18.95%		2402	21.70%		2509	24.46%		2087	19.40%	
very high	303	2.57%		722	6.52%		705	6.87%		625	5.81%	

younger age groups (young children, children, and adolescent). Thus, the younger the group, the more imbalanced the gender ratio. Such gender imbalance correctly reflects the sexual bias in China due to the son-preference and selective abortion after the implementation of the One Child Policy. About 65% of the sample lives in rural area, which is close to the national average. Over the survey period, there is a slight increase of urbanization in our sample. Education also increases during the survey years as more people are having high-school and college education than before. Income increases substantially in 1993 and 1997 and then dropped in 2000[20]. It is probably

[20] The income level in the CHNS data has been found a little bit higher than the income level from other surveys in China, which is mainly due to a slightly higher fraction of suburban households in the CHNS rural sample (Benjamin, Brandt, and Giles, 2005).

related to the changes of farm procurement prices, which greatly affected the rural households for whom farming was an important source of income. As farm prices doubled in nominal terms between 1993 and 1995 and dropped afterwards (and did not catch up until 2002-2003), it is not surprising that household income increased in 1993 and 1997, but decreased in 2000. Finally, of all the households, about 23% are families with only one child, 67% are with more than one child, and the remaining 10% are those with no children.

Overall, the mean per household calorie adequacy is .9433 calories and the mean calorie adequacy for individuals is .9450 calories for all years. For each age group, the average calorie adequacy is .7998 for young children, .8826 for children, .8919 for adolescent, .9664 for prime age adult and .9974 for the elderly. A more specific description of calorie adequacy for each sub-group is presented in Table 3.2. In general, females are better-off than males; older age groups are better-off than younger age groups, the rural are better-off than the urban, the poor is better-off than the rich, no child is better than having child, in terms of calorie adequacy. Female elderly group is the only subgroup that has a mean calorie adequacy greater than one. In other words, all the other groups suffer from different degree of under-nutrition in our sample.

Table 3.2 Calorie adequacy for each sub-group in the CHNS sample for all years

Variable	N	%	Mean Calorie Adequacy
Age			
young children	2130	3.16	0.800
children	3964	5.88	0.883
adolescents	7243	10.74	0.892
adults	24648	36.56	0.966
elderly	7841	11.63	0.997
Gender			
male	33225	49.28	0.926
female	33648	49.91	0.964
Education			
primary	21271	31.55	0.963
middle	18918	28.06	0.963
high	25115	37.25	0.922
college	1569	2.33	0.931
Rural affiliation			
urban	20454	30.34	0.924
Rural	46419	68.85	0.956
Household Income			
very low	17284	25.64	0.958
low	16906	25.08	0.952
middle	15869	23.54	0.937
high	11793	17.49	0.928
very high	2767	4.10	0.947
One child status			
No child	6955	10.32	0.972
One child	17556	26.04	0.923
More than one	42362	62.83	0.951
Total	45818		0.945

3.4 Under-nutrition (Nutrition Poverty) Analysis

Concept

We use poverty measurements suggest by Foster, Greer and Thorbecke (1984) to analyze under-nutrition in the CHNS data. Given the information of each individual's nutrition status (φ) and a nutrition poverty line (z), the F-G-T measures under-nutrition at an aggregate level. The technique is first introduced by Kakwani (1989) and

Ravallion (1990) and later adopted and modified by Haddad and Kanbur (1990, 1993). Specifically, the equation of the poverty measurement is given by:

(1) $$P_\alpha = \int_0^z \left(\frac{z-\varphi}{z}\right)^\alpha f(\varphi)d\varphi$$

Where φ is each individual's nutritional status, which is calorie adequacy in this study and f(α) is the frequency density of calorie adequacy in the population. Z is the nutrition poverty line, in our study it is 1 since when calorie adequacy is less than 1, a person is not taking enough calories according to his/her calorie requirement and therefore is considered under-nourished.

With α being 0, 1 and 2, equation (1) measures the headcount ratio of undernourished population, the aggregate nutrition gap and the under-nutrition severity index. [21] The headcount ratio estimates the proportion of population which is undernourished, but it does not take into account the intensity of under-nutrition suffered by the population because it does not make a distinction between the mild and severe forms of under-nutrition suffered by an individual. The aggregate nutrition gap sums the difference between the calorie requirement and intake for each individual who is undernourished and therefore, takes into account of the total nutrition shortfall. The under-nutrition severity index multiplies nutrition gap by itself and therefore those who suffer from severe hunger get more weight in the total under-nutrition measure than those who suffer from mild hunger. For that reason, it is called the nutrition severity index. As a result, with α increasing, P_α gives more and more weight to those at the low end of nutrition achievement.

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[21] Accordingly, in the poverty literature, α = 0, 1 and 2 each represents poverty headcount ratio, the poverty gap index and the poverty severity index.

One advantage of using $P_{\alpha,}$ is that it is a class of decomposable measures, which allow us to decompose the aggregate under-nutrition between different subgroups. Since the main task of this study is to identify those at a disadvantaged in the household, the decomposition technique allows us to look at the under-nutrition status of each household member. The decomposition can be conducted along the lines of age, gender, residential affiliation, occupation, etc. If we write

$$(2)\quad f(\varphi) = f(\varphi, t) = a(\varphi \mid t)h(t),$$

where t is one characteristic that divides the population into different subgroups such as age or gender, a(φ|t) is the conditional density of φ given t, and h(t) is the marginal density of t in the population, then equation (1) can be rewritten as

$$(3)\quad \begin{aligned} P_\alpha &= \int_0^\infty \left[\int_0^z \left(\frac{z-\varphi}{z}\right)^\alpha a(\varphi \mid t)d\varphi\right]h(t)dt \\ &= \int_0^\infty P_\alpha(t)h(t)dt \end{aligned}.$$

where, (3) indicates that total under-nutrition (poverty) is the sum of under-nutrition of each subgroup in the population based on t and is weighted by the marginal density (proportion in the population) of that group in the population.

Results

Using CHNS data, under-nutrition, or nutrition poverty, is presented in Table 3.3. The first row in the left half of Table 3.3 presents the values of P_0, P_1 and P_2 for the total population. The headcount ratio (P_0) is 62.46%, indicating that the CHNS sample is largely undernourished with more than 60% of the population under the nutrition poverty line. Poverty gap P_1 shows that on average, undernourished people have to increase their calorie adequacy by almost 15% to go above the poverty line. Poverty severity index P_2 lacks of intuitive interpretation. But since it puts more weight on observations on the low end of the nutrition distribution, it becomes useful when comparing the nutritional severity between two populations.

Table 3.3 also decomposes P_0, P_1 and P_2 into different subgroups. Along provincial line, we find that the province of Heilongjiang suffers the most from under-nutrition, with more than 80% of its population under-nourished, and have to increase their calorie adequacy by a quarter to be above the poverty line. Comparatively, the province Guizhou has a little over half of the population under the nutrition poverty line and the lowest severity index of under-nutrition. Households with only one child suffer slightly more from under-nutrition than households with multiple children though the difference is not significant. In terms of age, under-nutrition increases with decreasing age. In particular, among young children, children, and adolescents, under-nutrition rates are all higher than 70%, and almost 80% for the youngest group (6 years old and under). Comparably, adults and elderly suffer less from under-nutrition, albeit the nutrition poverty headcount ratios of both are still over 55%. According to P1, to make up for the nutrition shortfall, young children (six and under) need to increase their calorie intake by 26% relative to their requirements, followed by children and adolescents by 17-18%, and adults and elderly by 12-13%. Table 3.3 also indicates that females in general are better off than males, rural population is better off than urban population in terms of calorie adequacy.

Compared to previous studies of the nutritional status of the Chinese population, there is more under-nutrition found in our study. The difference is so significant that we have to ask what causes the large difference between results from others and from us. One important reason might be that in most other studies, young children (6 and under) and sometime children (6-10) are not included, whereas our results have shown that these are the two groups that suffer the severest under-nutrition among all age groups. Therefore, by omitting the young children and children, some of the previous studies might under-estimate the severity of under-nutrition. For adults, who compose more than 60% of our sample, we argue that many of them have experienced mal-nutrition during their youth in the Culture Revolution, when mass hunger was wide-spread in China; as a result these adults tend to have small figures. For example, Zhen and Chen (2005) have shown significant body height increase in the past 3 decades. Therefore, with a large body of short adults, the BMI measures in previous studies might over-estimate the scale of over-weight and obesity since the denominator in the BMI formula is height square. In addition, there might be under-reporting of food intake in the CHNS sample, which would leads to over-estimation of under-nutrition in our analysis. However, even with these caveats, the prevalence of low calorie adequacies, in particular among children and adolescents, is striking and should not be ignored even as obesity has also become a problem in China.

Table 3.3 Subgroup FGT index estimates

	Subgroup FGT index estimates			Percentage Group Contribution to P_α		
Group	**$P_0(\Phi)$**	**$P_1(\Phi)$**	**$P_2(\Phi)$**	**P_0%**	**P_1%**	**P_2%**
All	0.6246	0.14573	0.05017	100	100	100
Province						
Liaoning	0.67779	0.17725	0.06427	9.4	10.6	11.1
Heilongjiang	0.82796	0.25365	0.10245	7.1	9.3	10.9
Jiangsu	0.62943	0.13761	0.04364	12.2	11.4	10.5
Shangdong	0.64198	0.15489	0.05536	11.2	11.6	12.1
Henan	0.59369	0.1396	0.04783	10.7	10.8	10.8

Table 3.3 (continued)						
Hubei	0.60919	0.14871	0.05317	12.2	12.8	13.3
Hunan	0.60419	0.12539	0.04198	11.2	10	9.7
Guangxi	0.64371	0.1316	0.0394	14	12.3	10.7
Guizhou	0.52588	0.11613	0.03907	11.8	11.2	10.9
One Child						
HH w/one	0.65376	0.15787	0.05521	35.1	36.2	36.6
HH w/one+	0.61475	0.14173	0.0487	64.9	63.8	63.4
Age group						
Young						
Children	0.78786	0.26132	0.11566	5.9	8.3	10.7
Children	0.70563	0.18147	0.065	9.8	10.8	11.2
Adolescents	0.69902	0.17362	0.0609	17.7	18.8	19.2
Adults	0.59934	0.12939	0.042	51.6	47.8	45
Elderly	0.55006	0.1219	0.04072	15.1	14.3	13.9
Gender						
Male	0.65275	0.156	0.05455	51.1	52.4	53.2
Female	0.59557	0.13547	0.04586	48.9	47.6	46.8
Residential						
Urban	0.65131	0.15374	0.05244	33.5	33.9	33.6
Rural	0.61036	0.1416	0.049	66.5	66.1	66.4

3.5 Inequality analysis

While the nutritional poverty analysis looks at individuals and households who are at the low end of the nutrition distribution, inequality analysis broadens the concept of poverty because it looks at the distribution of nutrition over the entire population and is not just for the population below a certain point.

Concepts

There are many ways to measure inequality. The most commonly used ones include the Gini coefficient, Atkinson's inequality measures, and generalized entropy measures (World Bank, 2005). Specifically for the generalized entropy measures (GE), the formula is given by:

$$(4)\ GE(\alpha) = \frac{1}{\alpha(\alpha-1)}\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_i}{\bar{y}}\right)^{\alpha} - 1\right]$$

Where y_i is individual i's calorie adequacy and $\bar{y}$ is the mean calorie adequacy. α represents the weight given to the distances between calorie adequacies at different parts of the nutrition distribution and commonly takes the value of 0, 1 and 2. The value of GE (α) can vary between 0 and ∞, with zero meaning total equality and the higher value representing a higher level of inequality. Notice that GE (α) is more sensitive to changes in the lower tail of the distribution when α is low and more sensitive to changes in the upper tail of the distribution when α is high. The Theil's Index is GE(1) and is chosen for this study due to its additive decomposability. The Theil's Index T is written as

$$(5)\ T = GE(1) = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\bar{y}}\ln(\frac{y_i}{\bar{y}}),$$

To decompose T, we can rewrite (5) as

$$(6)\ \begin{aligned} T &= \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\bar{y}}\ln(\frac{y_i}{\bar{y}}) = \sum_{i=1}^{N}\frac{y_i}{N\bar{y}}\ln\left(\frac{y_i N}{\bar{y}N}\right) = \sum_{i=1}^{N}\frac{y_i}{\bar{y}}\ln\left(\frac{y_i N}{Y}\right) \\ &= \sum_j\left(\frac{Y_j}{Y}\right)T_j + \sum\left(\frac{Y_j}{Y}\right)\ln\left(\frac{Y_j / Y}{N_j / N}\right) \end{aligned},$$

where N is the total population, N_j is the population in the subgroup, Y is the total calorie adequacy of the population and Y_j is the total calorie adequacy of the subgroup.

Equation (6) shows that T can be decomposed into two components. The first term represents the within-group inequality and the second term represents the between-group inequality. If we want to compare the inequality between different subgroups of the population, we can look at the decomposed inequality in each subgroup. Therefore, we can divide the total population along age, gender, rural and urban, occupation etc. The within-group inequality shows the contribution of the inequality within each subgroup to the total inequality of the population, it can be considered the share of each subgroup's inequality among the total inequality. The between-group inequality shows the contribution of the difference between each subgroup to the total inequality.

As for intra-household inequality, Haddad and Kanbur (1990) suggest the difference between the inequalities using individual level data and household level data is intra-household inequality. They use data from the Philippines and find that intra-household inequality makes up an important part of total inequality, ranging from 60% for the log-variance to 35% for the Gini coefficient. Specifically, three inequalities are calculated based on the following three calorie adequacies,

$$\phi i = C i / R i$$

$$\phi 1 i = \frac{1}{n_h} \sum_{i=1}^{n_h} \phi i$$

$$\phi 2 i = \frac{\sum_{i=1}^{n_h} C i}{\sum_{i=1}^{n_h} R i}$$

, where **Ci** = calorie intake of individual i

Ri = calorie requirement of individual i

Φi = calorie adequacy ratio of individual i

nh = number of individuals in household h

Φ1i =mean of individual calorie adequacy within the household

Φ2i =household calorie adequacy

We have measured differences between the inequality measures of Φ and Φ1 (or Φ2). Using this approach, if there is no intra-household inequality and each individual in the household has the same calorie adequacy, Φ, Φ1, and Φ2 should be the same. If Φ and Φ1 (or Φ2) differ, then there is intra-household inequality. This method, however, does not directly tell the exact level of intra-household inequality for each household. It is rather an indirect way of revealing intra-household inequality by observing the difference between the individual-level average and household-level average.

In fact, if individual level data is available, one can directly calculate an inequality value for each household. For example, we can calculate a Theil's index for each household using equation (5). Here, yi is each individual's calorie adequacy, y bar is the mean individual calorie adequacy inside the household and N is the number of household members. By calculating the intra-household inequality level inside of each household, we can compare the intra-household inequalities among different demographic groups and identify those with an advantage or disadvantage.

Results

Table 3.3 presents different inequality measures using Φ, Φ1 and Φ2. Φ is individual calorie adequacy, Φ1 is mean calorie adequacy in the household, and Φ2 is household calorie adequacy. The difference between Φ1 and Φ2 is that Φ1 is an average of Φ in the household; while Φ2 is the ratio between household total calorie intake and household total energy requirement. Though both Φ1 and Φ2 are at the household level, Φ2 is considered cruder than Φ1 as it does not contain any individual information in its value.

Clearly, intra-household inequality exists in the CHNS data as is shown by the difference between Φ (individual level) and Φ1 (household average) and Φ2 (average household) in Table 3.4. The gap ranges from 15% for mean deviation and Gini coefficient to 30% for Theil's index and Mean Log Deviation.

We also explore the extent of subgroup inequalities in the second column in Table 3.5. Since Theil's Index is additively decomposable, we conduct decompositions of the inequality along provincial, gender, age and rural/urban lines. Specifically, in terms of geographic location, the province of Heilongjiang experiences the highest inequality and the province of Guangxi the lowest, among all the provinces. Inequality is also higher in rural areas than in urban areas. Age-wise, young children contribute the most inequality relative to the rest of the age groups. No significant difference exists between males and females. Underneath each subgroup inequality, we present the within-group inequality and the between-group inequality. Among all subgroups, the within-group inequality is found always larger than the between-group inequality, which suggests that inequality is more of a problem within each subgroups than between them.

Mean intra-household inequality for each subgroup is presented in the third column in Table 3.5. This is done by first calculating an inequality measure using Theil's Index for each household, then calculating the mean of the Theil's Index for each subgroup.

We find the mean of intra-household Theil's inequality for the entire sample is .01115, around 18% of total inequality which is 0.05 for Theil's index. For each subgroup, we find those who contribute more to the total inequality also experience more intra-household inequality, such as the province of Heilongjiang and the young children age group are among the higher intra-household inequality groups. The only exception is that while the rural sample contributes more to the total inequality than the urban sample, intra-household inequality in the rural areas, however, is lower than intra-household inequality in the urban areas. A possible explanation could be that inequality in rural areas is mainly caused by between-household inequality instead of within-household inequality, and the between-household inequality in rural areas is greater than in urban areas.

In short, intra-household inequality not only exists in the CHNS data, but also varies among different demographic groups. Using different level data (individual versus household), the inequality level may vary substantially.

Table 3.4 Existence of intra-household inequality

Inequality measures for	Φ	Φ1	Φ2
Relative mean deviation	0.1201	0.1010	0.1009
Coefficient of variation	0.3211	0.2666	0.2659
Standard deviation of logs	0.3329	0.2775	0.2774
Gini coefficient	0.1724	0.1451	0.1449
Mehran measure	0.2488	0.2105	0.2103
Piesch measure	0.1341	0.1124	0.1122
Kakwani measure	0.0287	0.0204	0.0203
Theil index (GE(a), a = 1)	0.0496	0.0348	0.0347

Table 3.4 (continued)

Mean Log Deviation (GE(a), a = 0)	0.0518	0.0362	0.0362
Entropy index (GE(a), a = -1)	0.0618	0.0423	0.0423
Half (Coeff.Var. squared) (GE(a), a = 2)	0.0516	0.0355	0.0354

Table 3.5 Decomposition of Theil inequality measures and mean of intra-household

	Decomposition	mean of intra-household
Total	0.0496	0.0112
Liaoning	0.0529	0.0124
Heilongjiang	0.0569	0.0154
Jiangsu	0.0456	0.0098
Shangdong	0.0532	0.0126
Henan	0.0554	0.0114
Hubei	0.0495	0.0108
Hunan	0.0414	0.0087
Guangxi	0.0349	0.0097
Guizhou	0.0520	0.0126
Within-group inequality	0.0482	
Between-group inequality	0.0014	
urban	0.0466	0.0118
Rural	0.0508	0.0108
Within-group inequality	0.0495	
Between-group inequality	0.0001	
Male	0.0497	0.0111

Table 3.5 (continued)

Female	0.0491	0.0112
Within-group inequality		
	0.0494	
Between-group inequality		
	0.0002	
Young Children	0.0861	0.0228
Children	0.0493	0.0148
Adolescents	0.0480	0.0123
Adults	0.0447	0.0125
Elderly	0.0499	0.0107
Within-group inequality		
	0.0482	
Between-group inequality		
	0.0014	

3.6 Is there a nutritional Kuznets Curve in China?

In 1955, economist Simon Kuznets proposed that with per capita income increases, inequality in a nation increases over time, then at a critical point begins to decrease. The relationship between inequality and average well-being is graphically represented by an inverted U curve, the Kuznets Curve, with inequality on the Y axis and average wellbeing, or per capita incomes on the X axis. Subsequent studies have attempted to test the existence of Kuznets Curve, among which not only nation level inequality, but also micro-level inequality, such as intra-household inequality, was considered. Empirically, some suggested that increase in the average household well-being does not necessarily reduce intra-household inequality (Sen, 1984; Harriss, 1990; Haddad, Hoddinott and Alderman, 1994). For example, Haddad and Kanbur (1990) found an inverted-U using the Philippine data where intra-household inequality first increases with average household wellbeing and then decreases at a critical point. If this is the case, then policies trying to improve the average well-being of the household may not be beneficial to certain household members as it may enlarge the inequality level inside of the household and hurt the disadvantaged members. Therefore, knowing the relationship between average nutrition status and nutrition inequality inside of the household may be of important policy significance. We use the CHNS data to investigate whether and how inequality in the household changes with changes in the average nutritional welfare in the household. In other words, if average nutritional welfare (such as calorie adequacy) in the household increases, does intra-household inequality also follow an inverted U in our sample after controlling for household characteristics such as household income and household composition?

Our study follows that of Haddad and Kanbur's Pilipino Study in 1991 and 1993. Specifically, we calculate a Theil's index for each household, which represents the intra-household inequality, as the dependent variable. Then we calculate the average calorie adequacy (Φ1) for each household to stand for the average well-being inside of the household, as the independent variable. In order to look for the interactive pattern between these two, we take the log of the Theil's index to make it vary in a larger range. We also include a set of control variables such as household income and household age/gender composition (details explained below).

In order to find the critical tuning point suggested by Kuznets, we conduct a simple grid search for the spline cutoffs over the range of average household calorie adequacy (Φ1). We assume a linear function between the independent variable Φ1 and the dependent variable, the log of the Theil's index (Log T) and make sure the cutoff points minimize the residual sum of squares for the regression. The spline technique is considered less restrictive than functional forms that involve a transformation of Φ1 (Stewart and Wallis, 1987). The only restrictions for the fitted curve are (1) the line segments are linear and (2) consecutive segments meet at the boundaries. We find two significant grids by first doing a crude grid search over the entire range of Φ1 and a fine grid search that falls into the neighborhood of the first-stage minimum. Two cutoff points occur at 1 and 1.2.

Using the values of the two grids, we are able to separate the sample into 3 sub-samples, they are, households whose average calorie adequacy in the household (Φ1) is less than 1, between 1 and 1.2 and greater than 1.2. Ordinary Least Square (OLS) regressions are conducted for each sub-sample and the coefficients of average calorie adequacy with respect to log of the Theil's Index are estimated. It is with the intention of finding a nutritional Kuznets Curve that we choose OLS since we are more interested in the sign of the slope rather than the exact magnitude of the coefficients. A set of control variables are included, such as household per capita income (pcinc), and the numbers of females and males in each age group, including total male of young children (tm1), total female of young children (tf1), total male of children (tm2), total female of children (tf2), total male of adolescents (tm3), total female of adolescents (tf3), total male of adults (tm4), total female of adults (tf4), total male of elderly (tm5) and total female of elderly(tf5).

Table 3.6 shows the regression results for each of the three sub-samples. The slopes of the three regressions suggest a U-shape in the sample. Specifically, when **Φ1** is less than 1, there is a significantly negative relationship (the coefficient is -1.13) between average calorie adequacy within the household and intra-household inequality (represented by log of Theil's index). In other words, for households who are undernourished (since their calorie adequacy is less than one), increases in average calorie adequacy within the household lessens intra-household inequality. The relationship is weakened (the coefficient is -0.357) when the value of **Φ1** is between 1 and 2, albeit still negative and significant. After **Φ1** becomes greater than 1.2, the relationship (the coefficient is 0.878) is reversed. That is, intra-household inequality increases with average well-being after the household average calorie adequacy becomes greater than 1.2. In contrast to the inversed-U shape that was found in the Pilipino data, there is a U shape relationship between intra-household inequality (logT) and average household calorie adequacy (**Φ1)** in the CHNS data. Yet we notice that inequality only increases after the average household calorie adequacy gets to 1.2, where only 16.7% of the sample is able to reach. Therefore, the findings are of significant policy values since the majority (62%) of our sample is still undernourished and an improvement in their nutritional status is beneficial to alleviating intra-household inequality.

Table 3.6 Regression analysis between calorie adequacy inequality (logT) and mean calorie adequacy within the household Φ1: three segments based on grid search

	logT	Coef.	Std. Err.	t	t p P>t	95% Conf.	Interval
Φ1<1	**Φ1**	-1.129	0.063	-17.950	0.000	-1.253	-1.006
	pcinc	0.000	0.000	3.170	0.002	0.000	0.000
	tm1	0.928	0.027	34.420	0.000	0.875	0.980
	tf1	0.887	0.029	30.450	0.000	0.830	0.944
	tm2	0.549	0.021	26.080	0.000	0.508	0.591
	tf2	0.518	0.021	24.500	0.000	0.477	0.560
	tm3	0.573	0.017	33.680	0.000	0.540	0.607
	tf3	0.371	0.016	23.580	0.000	0.341	0.402
	tm4	0.428	0.015	27.680	0.000	0.397	0.458
	tf4	0.383	0.017	23.090	0.000	0.350	0.415
	tm5	0.286	0.024	11.840	0.000	0.239	0.333

Table 3.6 (continued)

	tf5	0.428	0.023	18.680	0.000	0.383	0.473
	constant	-5.980	0.057	-104.900	0.000	-6.091	-5.868
	Φ1	-0.357	0.029	-12.500	0.000	-0.413	-0.301
1<Φ1<1.2	pcinc	0.000	0.000	4.630	0.000	0.000	0.000
	tm1	0.934	0.023	41.290	0.000	0.890	0.979
	tf1	0.872	0.024	36.640	0.000	0.826	0.919
	tm2	0.555	0.017	32.870	0.000	0.522	0.588
	tf2	0.513	0.017	29.430	0.000	0.479	0.547
	tm3	0.563	0.014	41.710	0.000	0.537	0.590
	tf3	0.342	0.013	27.090	0.000	0.318	0.367
	tm4	0.405	0.013	32.280	0.000	0.380	0.429
	tf4	0.352	0.013	26.970	0.000	0.327	0.378
	tm5	0.250	0.020	12.690	0.000	0.211	0.288
	tf5	0.487	0.019	26.210	0.000	0.451	0.524
	constant	-6.545	0.037	-176.960	0.000	-6.617	-6.472
	Φ1	0.878	0.112	7.860	0.000	0.659	1.097
	pcinc	0.000	0.000	4.870	0.000	0.000	0.000
Φ1>1.2	tm1	1.041	0.070	14.780	0.000	0.903	1.179
	tf1	0.885	0.082	10.830	0.000	0.725	1.045
	tm2	0.701	0.053	13.340	0.000	0.598	0.804
	tf2	0.465	0.051	9.200	0.000	0.366	0.564
	tm3	0.587	0.038	15.480	0.000	0.513	0.661
	tf3	0.345	0.037	9.430	0.000	0.273	0.417
	tm4	0.457	0.038	12.010	0.000	0.383	0.532
	tf4	0.323	0.036	9.090	0.000	0.254	0.393
	tm5	0.319	0.058	5.480	0.000	0.205	0.433
	tf5	0.583	0.053	11.000	0.000	0.479	0.687
	constant	-8.360	0.180	-46.570	0.000	-8.712	-8.008

The demographic variables all increase intra-household inequality in the regression with the biggest effects from the number of young children and children, especially males in the household. This could be due to the high cost of raising children in the Chinese household and an ever higher cost of male children due to son preference. Per capital income has almost no effect on intra-household nutritional inequality. One explanation could be that income is not directly related to food intake in China, especially in rural areas where most people grow food themselves and do not have to purchase them with their limited income.

Finally, we examine heteroscedasticity with a White test (Maddala, 1988) on the residues of the linear spline function. The result rejects the null hypothesis of homoscedasticity regarding household size. A Weighted Least Squares (WLS) model is estimated and the coefficients are close to the estimation from OLS, which shows that heteroscedasticity does not affect the spline grid search based on OLS estimate.

In sum, we find a U-shaped relationship between intra-household inequality and average household wellbeing. The cut-off points happen to be 1 and 1.2, meaning before households reach an average calorie adequacy equal to 1.2, intra-household inequality decreases with average household wellbeing. In other words, for almost 90% (86%) of the sample, they experience decreasing intra-household inequality with improvement in average household wellbeing. This is different from Haddad and Kanbur (1990)'s study in the Philippines that finds an inverted-U shape between the two with improvement in household average wellbeing first increasing and then decreasing intra-household inequality. One explanation for the different results could be that average calorie adequacy in our data does not truly represent household wellbeing. In fact, the correlation between calorie adequacy and household average income is significantly negative, suggesting that calorie adequacy in the CHNS data might not be a good candidate for household wellbeing as it is in the Philippine data. But if we only consider the nutritional status of the population, a U shape relationship simply implies that households with very low household calorie adequacy and household with very high calorie adequacy are among those with high intra-household inequality in terms of calorie intake and therefore warrant more policy consideration. In fact, with the majority of the sample are on the decreasing side of the U shape curve, the policy implication is very obvious, that is, improvement in average household nutritional status helps reduce intra-household inequality.

3.7 Targeting

Recognizing the existence of intra-household inequality is potentially helpful for better targeting. It helps to be aware that interventions to improve average household wellbeing do not necessarily help individuals in the household. Therefore, identifying those who are at a disadvantage in the household provides policy makers a better rationale to target. The main aspect of targeting is to know how to identify disadvantaged groups. For example, if it is the case that young household members are a vulnerable group, then interventions should be directed at those households with children.

Although much of the evidence is suggestive rather than definitive, our results show that a U shape relationship clearly exists between intra-household calorie adequacy and average household well being. In particular, the negative relationship between the two before calorie adequacy reach 1.2, where the majority of the data could not reach, suggests targeting calorie deficient households is an effective way of intervention. By targeting at households whose average calorie adequacy is less than 1.2, not only under-nutrition is alleviated since fewer households will be undernourished, but also intra-household inequality is lessened since intra-household inequality deceases with improvement in average household calorie adequacy before it reaches 1.2. Therefore, an intuitive and direct intervention is to target at households who are undernourished. But the question is how to identify those households who are under the nutrition poverty line. It calls for information on the average household calorie adequacy, which requires detailed information on calorie intake of each individual in the household. Such information, however, is not always available and the collection of which is very costly. Are there other targeting strategies that allow interventions to easily target and effectively alleviating both under-nutrition and intra-household inequality?

Age or gender is easily observable and usually available in most surveys, which make them good candidate for indicator targeting. We choose age as an indicator since age inequality is severer than gender inequality in our sample. A framework of upper age limit targeting is therefore presented as follows.

Upper age limit targeting is designed to set up an age limit so that only individuals under the age limit are eligible for policy intervention such as nutrition supplement. We assume the total amount of transfer is equally distributed among individuals who meet the criterion, that is, their age is under the upper age limit. Clearly, the more eligible individuals in the targeting program, the less supplement each person gets. Therefore, when more people are in the targeting pool, the nutrition poverty gap does not necessary decrease since many still remain undernourished because the transfer is too little. Hence, the main goal of upper age limit targeting is to find out the upper age limit that minimizes the nutrition poverty gap (P1) in the population with a given amount of transfer. A more complete discussion of upper age limit targeting can be found in Haddad and Kanbur (1993).

We use data from CHNS 2000 to conduct the analysis of upper age limit targeting. Figure 3.1 shows the mean calorie adequacy for each age group in the sample. Before age 70, mean calorie adequacy increases with age. Accordingly, Figure 3.2 shows the nutrition poverty gap (nutrition deficit) for each age group. Before the age 60, there is less nutrition deficit as age increases. In other word, there is more under-nutrition among the young age groups than among the old age groups. More nutritional supplements are needed in the young age groups.

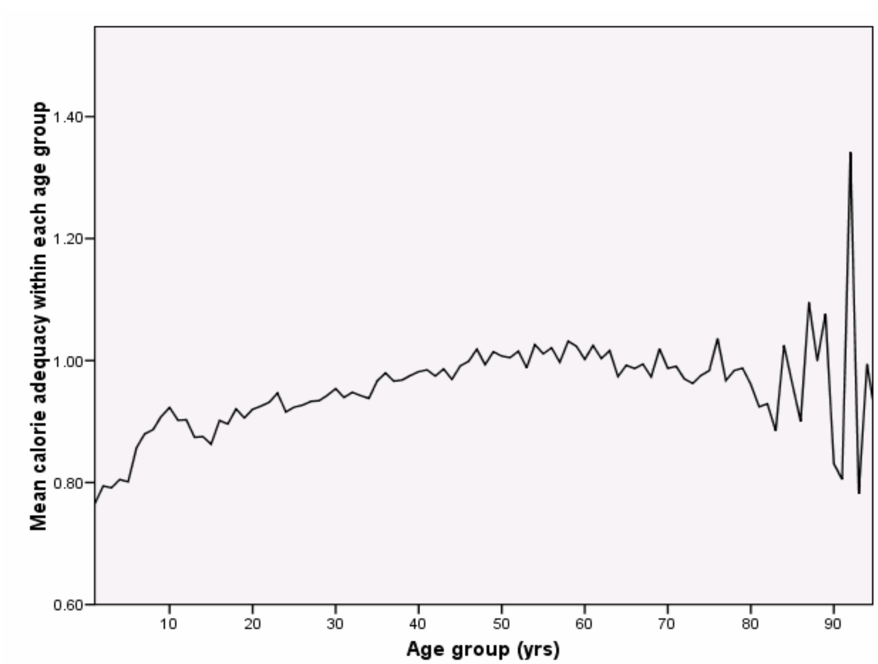

Figure 3.1: Mean calorie adequacy within each age group in CHNS 2000

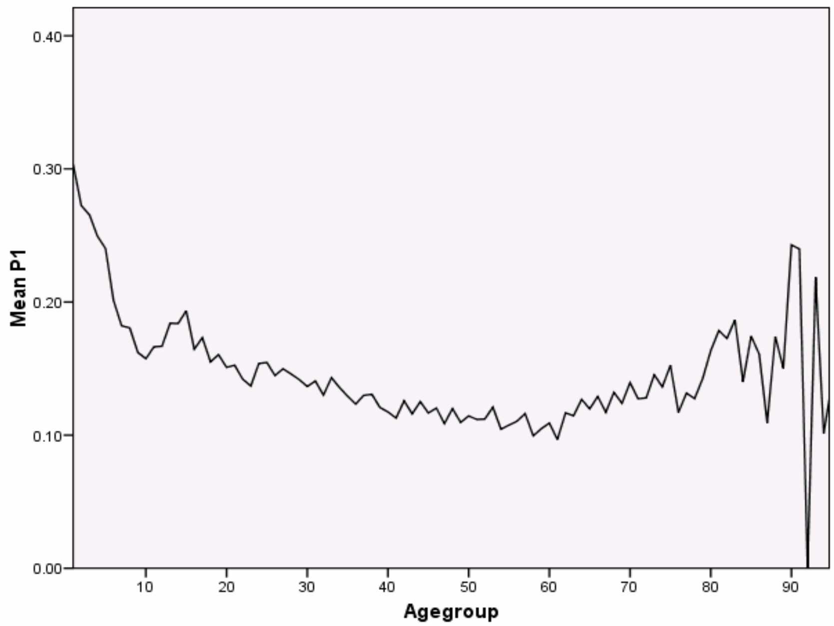

Figure 3.2: Nutrition poverty gap (P1) for each age group based on individual calorie adequacy in CHNS 2000

Theoretically, 4,829,121 calories are needed to alleviate the nutrition deficit for all age groups in the CHNS 2000 sample. The figure is a sum of the nutritional gap of all the individuals in the sample that are below the nutrition poverty line. But in reality, only a limited amount of nutrition supplement is available. Once the upper age limit is determined, everyone under the age limit will get the supplement no matter what their nutritional status is. Therefore, with an age limit increase, there are more and more people who are not under-nourished but will share the supplement in the pool, which leads to a decreased amount of supplement for those who are indeed under-nourished. Graphically, we describe the different under-nutrition situation with different amount of nutritional supplement in Figure 3.3, where P1 is nutrition poverty gap (nutrition deficit) and B is the different amount of nutrition supplement in million calories.

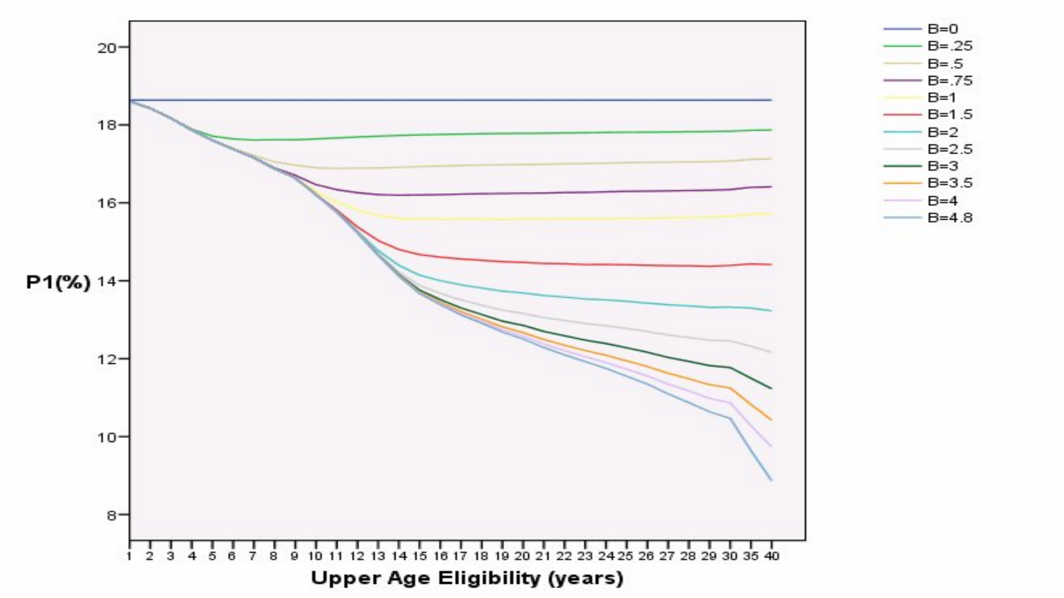

Figure 3.3 Nutritional gaps under different nutritional transfer intervention

In Figure 3.3, the top line is when B equals to 0, i.e. the nutrition transfer is 0, which shows no effect on nutrition poverty ratio P1. The lowest line is when the nutrition transfer is 4.8 million calories, an amount almost equal to the total nutrition deficit, and it decreases P1 substantially. According to the different decreasing patterns of various amount of B, when B is greater than 2.5 million calories, an amount more than half of the nutrition deficit, P1 decreases with upper age limit, even after age reaches 30 years old. When the transfer is less than 2.5 million calories, however, P1 first falls rapidly up to a certain age and then decreases at a slower speed until constant or even increases a little bit. Obviously, the effect of bringing more people out of under-nutrition no longer dominates the effect of spreading resources thinly so that fewer people are able to alleviate their nutrition deficit. An optimal age limit can therefore be decided by the amount of transfer (B) and the minimum nutrition deficit (P1). Table 3.7 presents the values of the optimal upper age eligibility for various values of B.

Obviously, upper age limit increases with B since more people can get into the pool as there are more resources available.

Table 3.7 Optimal age cutoffs for various values of calorie intervention B (millions of calories)

	B=.25	B=.5	B=.75	B=1	B=1.5
Optimal age for P1	7	11	14	16	29

Some would argue that since we identify the disadvantaged groups are most young age groups and if the optimal age cutoffs are all for young ages, we only need to target at those households with children. But the above discussion does not consider leakage, that is, food-sharing among different household members. Haddad and Kanbur (1993) argue that food sharing may render age impotent as an indicator for targeting due to intra-household leakage. Therefore the validity of upper age limit targeting would better depend on a scheme that not only minimizes food leakage but also decreases intra-household inequality using other interventions. An example of minimizing food leakage would be to distribute food supplement at school rather than in the households since adults are less able to take away food from children at school than at home. An example to decrease intra-household inequality using interventions other than direct nutrition supplement could be to improve women's access to resources. Many studies have found that improving women's access to resources is usually beneficial to children's nutrition and health (Bennet, 1988; Abbi et al., 1991). In other words, if policies are targeting children's nutritional status, income transfer or food subsidy directly paid to women will be a better idea than giving them to the household heads, usually male.

To conclude, under a unitary model of the household whose decision-making is unitary, a lump-sum transfer is more preferred. But when intra-household inequality exists, such model no longer supports an efficient transfer. Therefore, policies that narrow the gap between male and female or between young and old will be more ideal. Upper age limit targeting is among the range of policies that target at age inequality in terms of nutritional distribution. Gender inequality, though less a problem in our sample, is still a problem in many other developing countries. For gender inequality, it may be alleviated if there is fairer health, schooling and wage allocation across male and female (Rogers and Schlossman, 1990). There is also a range of interventions in wage and price policies that may be used to reallocate resources within households as Alderman suggests that a price policy might be more efficient than lump-sum transfers since transfer programs are usually more costly (Alderman and Gertler, 1997).

3.8 Comparing individual data and household data

Many times in developing countries, only household-level data, instead of individual-level data like that used in this study, are available due to its low collecting cost. In that case, one only knows how much food the total household intakes, not how much each individual in the household intakes. Instead of getting a calorie adequacy of the household, a household calorie adequacy can be calculated, with information of total household calorie intake and total household nutrition requirement. Will there be any difference between using individual-level data and household-level data? If the answer is no, then we do not have to collect expensive individual-level data and rather choose to collect household level data to simplify the problem. Haddad and Kanbur (1990) discuss this issue using the Philippine data and found no significant difference between the results among household-level and individual-level data. We continue this discussion using the CHNS data.

We compare nutritional poverty measures, inequality measures, and mean calorie adequacies within each age group using individual data and household data. The results can be found in Table 3.8, 3.9, 3.10 and 3.11, and figure 3.4 and 3,5. Φ represents individual calorie adequacy, $\Phi1$ is average calorie adequacy in the household, and $\Phi2$ is household calorie adequacy. The difference between $\Phi1$ and $\Phi2$ is that $\Phi1$ is an average of all the Φ in the household; while $\Phi2$ is the ratio of household total calorie intake and household total energy requirement. Though both $\Phi1$ and $\Phi2$ are at the household level, $\Phi2$ is considered cruder than $\Phi1$ as it does not contain any individual information in its value.

According to Table 3.8, while the nutritional poverty measures do not different substantially using Φ, $\Phi1$ and $\Phi2$, the inequality measures could vary about 15% to 30% using different level of data. In section four, we have already discussed that the difference between using the individual level data and household level data proves the existence of intra-household inequality. Using the decomposing technique, we can decompose both nutrition poverty and inequality into different subgroups in our sample. Table 3.9 thus shows the different rankings of poverty and inequality among different subgroups using Φ, $\Phi1$ and $\Phi2$. There are substantial differences between provinces and different age groups. In fact, the Spearman's rank correlation coefficients for inequality rankings of different provinces are 0.90 between using Φ and $\Phi1$, 0.31 between using Φ and $\Phi2$, and 0.46 between $\Phi1$ and $\Phi2$, indicating that the results are significantly different if we want to compare the inequality level for different provinces using individual level data and household level data. Also noticeable is the inequality rankings among gender and age groups. Using Φ and Φ1 (or Φ2), the rank could be reversed. Therefore, we further separate the sample into 10 different gender/age combinations in order to detect more difference. Table 3.8 and 3.9 show that while the poverty headcount ratios do not differ substantially using Φ, Φ1 and Φ2, the poverty gap and poverty severity index do vary dramatically when using Φ, Φ1 and Φ2.

Figure 3.4 shows that using Φ and Φ1, the Lorenz curves for calorie adequacy in the Chinese population differ. Figure 3.5 indicates that if we use household calorie adequacy to calculate the mean calorie adequacy for each age group, we get a completely different picture than using individual calorie adequacy. It is flatter and no longer shows a decreasing patter with age. This is all because of the neglect of intra-household inequality. The difference is critical for policy intervention since if we use household calorie adequacy instead of individual calorie adequacy, an upper age limit targeting will no longer appear to be valid.

In conclusion, while Haddad and Kanbur (Haddad and Kanbur, 1993) did not find much variation in patterns of inequality and poverty using individual level data and household level data in the Philippine sample, we do find substantial difference between the two in both poverty analysis and inequality analysis of the nutritional status in the Chinese data. The main reason is probably that in Haddad and Kanbur's study, the main subgroups are based on agriculture production and tenure status, while in our study no such categorizing exists. In fact, Haddad and Kanbur do find that individual level data is required when considering male and female groups since the poverty rankings are reversed when comparing Φ with Φ1 and Φ with Φ2. As a result, knowing individual data is essential in the Chinese setting as our data gives different information of both poverty and inequality based on individual data and household data.

Table 3.8 Poverty measures and inequality measures for the entire sample using Φ, Φ1 and Φ2

Poverty measures	Φ	Φ1	Φ2
Headcount ratio%	62.46	63.817	64.121
Poverty gap ratio %	14.573	12.818	12.887
Income gap ratio %	23.331	20.085	20.098
Index FGT(0.5) *100	28.105	26.626	26.762
Index FGT(1.5) *100	8.272	6.772	6.811
Index FGT(2.0) *100	5.017	3.833	3.857
Index FGT(2.5) *100	3.207	2.293	2.309
Index FGT(3.0) *100	2.141	1.439	1.45
Index FGT(3.5) *100	1.484	0.942	0.95
Index FGT(4.0) *100	1.063	0.642	0.647
Index FGT(4.5) *100	0.785	0.454	0.458
Index FGT(5.0) *100	0.596	0.333	0.336
Sen index *100	20.155	17.766	17.863
Inequality measures	**Φ**	**Φ1**	**Φ2**
Relative mean deviation	0.1201	0.101	0.1009
Coefficient of variation	0.3211	0.2666	0.2659
Standard deviation of logs	0.3329	0.2775	0.2774
Gini coefficient	0.1724	0.1451	0.1449
Mehran measure	0.2488	0.2105	0.2103
Piesch measure	0.1341	0.1124	0.1122
Kakwani measure	0.0287	0.0204	0.0203
Theil index (GE(a), a = 1)	0.0496	0.0348	0.0347

Table 3.9 Subgroup poverty and inequality rankings using Φ, Φ1 and Φ2

Theil inequality Rankings for subgroups				Poverty (P1) rankings for subgroups		
Group	Φ	Φ1	Φ2	Φ	Φ1	Φ2
Liaoning	6	7	7	8	8	7
Heilongjiang	9	8	8	9	9	9
Jiangsu	3	3	4	5	6	6
Shangdong	7	6	6	6	5	5
Henan	8	9	9	2	2	2
Hubei	4	5	5	4	3	3
Hunan	2	2	2	3	4	4
Guangxi	1	1	1	7	7	8
Guizhou	5	4	3	1	1	1
urban	1	1	1	2	2	2
Rural	2	2	2	1	1	1
Male	2	1	1	2	2	2
Female	1	2	2	1	1	1
Young Children	5	2	1	5	5	5
Children	3	1	2	4	4	2
Adolescents	2	3	3	3	2	3
Adults	1	4	4	2	3	4
Elderly	4	5	5	1	1	1

Table 3.10 Gender/Age Subgroup FGT index estimates using Φ, Φ1, Φ2

	P0(Φ)	**P1(Φ)**	**P2(Φ)**	**P0(Φ1)**	**P1(Φ1**	**P2(Φ1**	**P0(Φ2)**	**P1(Φ2**	**P2(Φ2**
M Young C	0.7959	0.2709	0.1210	0.6923	0.1439	0.0421	0.6717	0.1331	0.0379
M Children	0.7030	0.1784	0.0631	0.6374	0.1242	0.0360	0.6326	0.1221	0.0353
M Adolescents	0.7022	0.1803	0.0646	0.6317	0.1299	0.0396	0.6408	0.1340	0.0411
M Adults	0.6352	0.1403	0.0463	0.6427	0.1279	0.0381	0.6480	0.1291	0.0386
M Elderly	0.5863	0.1333	0.0451	0.6043	0.1230	0.0378	0.6113	0.1255	0.0388
F Young C	0.7764	0.2474	0.1070	0.6604	0.1343	0.0391	0.6448	0.1254	0.0354
F Children	0.7059	0.1851	0.0673	0.6618	0.1319	0.0392	0.6493	0.1283	0.0380
F Adolescents	0.6970	0.1664	0.0568	0.6417	0.1273	0.0378	0.6454	0.1288	0.0384
F Adults	0.5643	0.1192	0.0381	0.6427	0.1295	0.0388	0.6453	0.1304	0.0391
F Elderly	0.5160	0.1119	0.0369	0.6023	0.1198	0.0360	0.6128	0.1224	0.0370

Table 3.11 Spearman's correlation coefficients between poverty measures using Φ, Φ1 and Φ2

Spearman's correlation coefficients for AGE/GENDER		
P0(Φ)	P0(Φ1)	0.7112
P0(Φ)	P0(Φ2)	0.5273
P0(Φ1)	P0(Φ2)	0.8815
P1(Φ)	P1(Φ1)	0.8303
P1(Φ)	P1(Φ2)	0.2242
P1(Φ1)	P1(Φ2)	0.5394
P2(Φ)	P2(Φ1)	0.7073
P2(Φ)	P2(Φ2)	-0.3091
P2(Φ1)	P2(Φ2)	0.311

P0: poverty headcount ratio. P1: poverty gap. P2: poverty severity index

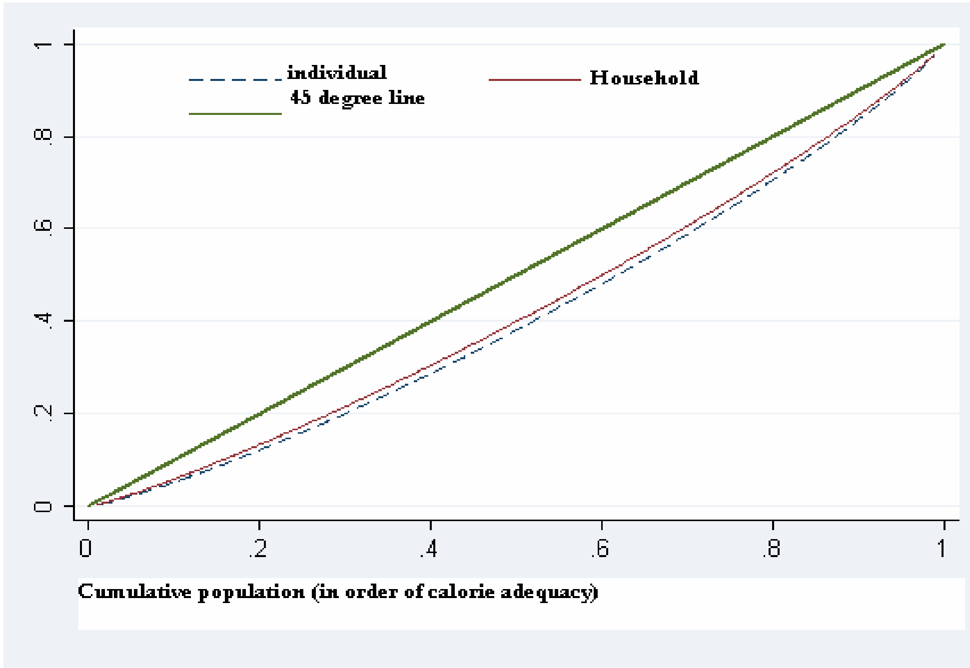

Figure 3.4 Lorenz curve of calorie adequacy among the CHNS sample suing Φ and Φ1

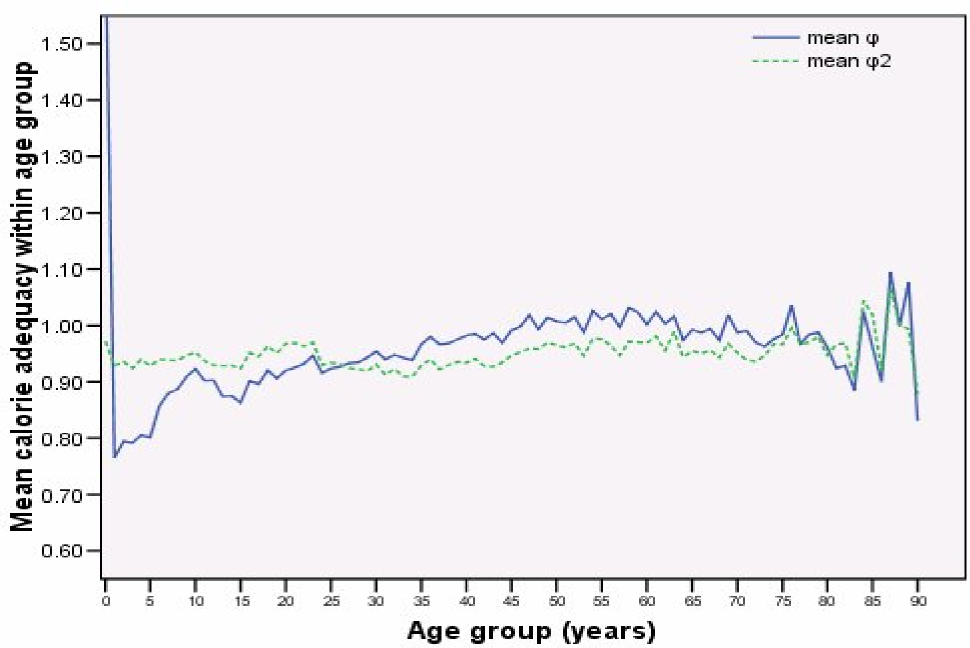

Figure 3.5 Mean calorie adequacies within different age group using Φ and Φ1

3.9 Conclusion

To conclude, we find large scale under-nutrition in the CHNS data from 1991 to 2000 using calorie intake. Over 60% of the population in the sample is undernourished with younger age groups suffering the most (over 70% for children and adolescents). After more than 20 years of the implementation of the One Child Policy in China, children's nutritional status is rather worrisome than what was suggested in previous studies. Adults and the elderly enjoy better nutrition intake but still remain largely under-nourished. Males are more likely to be under-nourished than females, which is contradictory to findings from other Asian countries. This could be that males' activity level is higher than female but do not get enough intake according to their activity level. Northern provinces such as Heilongjiang, Liaoning experience more under-nutrition than Southern provinces such as Hunan and Guizhou, which most probably is due to the different economic development in these provinces.

One disadvantage of calorie intake is that it does not take into account the quality and variety of different nutrients one is suppose to take, such as intakes of vitamins and minerals and therefore omit important information of the quality of nutritional intake. A study on micronutrients intake using the same data (CHNS) actually finds that micronutrient deficiencies are widespread, such as for Vitamin A and Calcium (Liu and Shankar, 2007). They find that on average, Chinese households are achieving only about half of the recommended micronutrient intakes, despite some slight improvement from 1997 to 2000. This result is rather consistent with what we find in our study in the sense that both show significant under-nutrition problem in China.

Another problem with our calorie adequacy analysis arises with our use of the US and Canada calorie requirements since some may argue that the calorie requirements for the US and Canada may not be applied to the Chinese population. We acknowledge there might be differences between the two populations. But on the other hand, why a healthy Chinese and a healthy American or Canadian should differ is still a problem in debate. As has been said before, the US and Canadian calorie intake requirement are created by calculating basal metabolic rates based on a healthy individual's age, gender, weight, height, pregnancy and lactation status, and activity pattern (Otton, etc., 2006). It is applied to all US and Canada population which include a large number of Asian and Chinese. We argue that the use of the US and Canada calorie requirements is appropriate as it is based on scientific evidences and precise research. It is the very reason why we do not use the DRIs developed by the Chinese Nutritional Society, as it does not consider weight, height and activity patterns for age 18 and under. The Chinese DRIs are also much cruder and simpler than the US and Canada requirements which is much more precise considering individual difference. In fact, our results show that using the DRIs from China lead to more under-nutrition in the CHNS data. Future studies may compare the differences of nutritional poverty and inequality using both sets of requirement and discuss the advantage and disadvantage of each.

Our results of under-nutrition are different from many previous studies that use anthropometric measures. Using BMI and other anthropometric measures, the scale of under-nutrition in China is not as severe as our results suggest. One disadvantage of using BMI is that the majority of the population is categorized as being "normal". Therefore it omits the possible vast variations in this "normal" group where many individuals may suffer from slight under-nutrition from time to time but manage to keep a normal BMI. Studies have shown that the body may adapt to a short period of under-nutrition as people become more efficient at absorbing and using some nutrients if they have low intakes (British Nutrition Foundation, 2005). Therefore, we believe that calorie intake is a better measure of the current nutritional status than BMI and other anthropometric measures. It is also sensitive and responsive to intra-household inequality as the relative status of each individual might change time to time. But calorie intake information in our study might suffer from mis-reporting and measurement error as it has been of concern that some individuals may omit foods, meals or snacks when they try to recall their diets for the past 24 hours (Goldberb R. R. et al, 1991), which would underestimate their food consumption. Therefore, the difference between our results and previous studies requires further research.

Intra-household inequality exists in the CHNS data. Though the scale is not as large as in some previous studies such as the Philippine studies conducted by Haddad and Kanbur (1990, 1993), significant differences are found between different demographic groups. In general, there are more intra-household inequalities among younger age groups than among older age groups; more in urban areas than in rural areas and more in Northern provinces than in Southern provinces. Further, those who suffer more from intra-household inequality are also those who experience more of under-nutrition. Although much of the evidence is suggestive rather than definitive, our results call for policy attentions for these disadvantaged groups as most of them also suffer more from under-nutrition.

The analysis of under-nutrition and intra-household inequality corresponds to a U-shape relationship between intra-household inequality and average household well being, which suggests that those who are at the low end, as well as the high end, of under-nourishment are more likely to experience high intra-household inequality. Therefore improving average nutritional status of under-nourished households not only addresses nutritional poverty but also improves intra-household inequality. Our discussion of upper age limit targeting suggests that there is always a trade-off between the depth and width of targeting. Nevertheless, more resources are desirable in any occasion. But the decision of upper age limit still entails careful research and discussion.

Last but not least, while targeting is aiming at the alleviation of poverty and inequality, policy can easily be shown to cause that poverty or inequality (Folbre, 1997). Sen (1990) argues that perceptions of self and personal welfare are both causes and results of inequalities. Therefore, understanding how policy may change the interaction inside of the household is equally important as identifying those who need help. A good monitoring system is needed during policy interventions to observe the possible changing dynamics in the households. But most importantly, more research is desired in intra-household inequality in China to correctly identify the poverty and inequality situation. For all things considered, errors in understanding intra-household allocation processes may mostly likely result in the failure of beneficial policies, or policies having unexpected consequences.

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