The SES gradient of biomarkers of cardiovascular disease risk in longevity areas in China

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INTRODUCTION

Population aging will be a major concern in China in the 21st century and it is important to study the health of the elderly, and the social and behavioral factors that influence elderly health. Moreover, China lags behind developed countries in economic and social welfare development, and is facing serious challenges of "growing old before it grows rich," with little research and preparation for an aging society. Clearly, there is an urgent public health need to investigate the factors that underlie healthy aging, especially among the oldest-old. In addition, although a large body of research documents an inverse relationship between socio-economic status and health in the U.S. and other western societies, it remains unclear whether this relationship exists at the oldest ages and whether this association is the same in developing countries.

In order to elucidate the connection between socio-economic status and health among an elderly population in China this research utilizes a unique dataset. This paper will analyze a village-based population survey, including both rural and urban residents, and in which medical personnel conducted a health exam and collected biomarker data from blood and urine samples. Only a limited number of population surveys also contain biomarkers, and even fewer of them are carried out in a developing country.

Studies have established the value of collecting/analyzing biomarkers along with socioeconomic and psychological information in population surveys (Crimmins and Seeman 2004; Crimmins and Seeman 2001). The rationale for including biomarkers is that they validate and add nuance to self-reports of health; they allow better modeling of pathways of influence between socioeconomic conditions and physical health, and they may capture aspects of health risk factors not included in respondents' self-reports (Weir 2008). For instance, high cholesterol may indicate preclinical or pre-morbid dysregulation which is unknown to survey participants, especially those living in rural areas without regular preventive health care. Or, for example, the CLHLS data show that among elderly aged 65-74, only 17% reported suffering from hypertension, but 51% were measured as having high blood pressure and may also have hypertension. Integrating biomarker data into analysis gives us a better understanding of the impact of social/behavioral factors on health (Turra, Goldman, Seplaki, Glei, Lin, and Weinstein 2005).

The purpose of this paper is to examine the extent to which socio-economic status predicts biomarkers of CVD risk among older adults residing in longevity areas in China. Is the relationship the same as in developed countries – an inverse relationship between SES and CVD? Or, do high SES people exhibit greater CVD risk because of increased exposure to unhealthy lifestyles such as a lack of exercise and a richer diet? (Rosero-Bixby and Dow 2009)

Cardiovascular disease is the number one cause of death in China, and previous research has shown that biomarkers of CVD risk are heavily influenced by social/behavioral factors (Harris, Gruenwald, and Seeman 2008), but we know very little about this relationship in the developing country context.

DATA AND METHODS

This paper uses survey and biomarker data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS). The sample includes middle-aged and older adults (ages 37-100+) living in seven designated "longevity areas" in China. Our study will only look at older adults age 60 and older. The survey interviews and village-based health exams, including blood/urine sample collection by medical personnel in the seven longevity areas, was carried out from February to June 2009. These seven selected longevity areas are among the eleven "Chinese

Longevity Areas (CLA)" formally designated by the Chinese Society of Gerontology (CSG). The CSG criteria include density of centenarians and nonagenarians, life expectancy, and a series of within-area consistency checks including general health status and environmental quality. The locations of the longevity areas in China are diverse, but include locales in Jiangsu, Hubei, Hunan, Sichuan, Henan, Shangdong, Hainan, Guandong, and Guanxi provinces. Table 1 below shows the distribution of the respondents in our data collection project by age and gender.

---Table 1---

Dependent Variables – Biomarkers of Cardiovascular Disease Risk

All of our dependent variables are coded as 0,1 dichotomous indicators, with 1 representing unfavorable conditions or events. Table 2a gives descriptive statistics for the dependent variables.

- Five specific biomarkers of CVD risk:
  - Abdominal girth: waist>80 cm women, 94 cm men
  - Diabetes: glycosylated hemoglobin⩾6.5%
  - High blood pressure: diastolic>90 and systolic>140 mmHg
  - High triglycerides in fasting serum: ⩾50 mg/dl
  - High Cholesterol Ratio: total to HDL ⩾5.92
- Number of specific biomarkers of CVD risk (out of 5).
- Having 1 or more, 2 or more, or 3 or more of the above CVD risk factors.
- Metabolic syndrome: high abdominal girth and at least 2 of the 4 conditions - diabetes, triglycerides, HDL cholesterol, and high blood pressure.

---Table 2a---

Independent Variables

Our key independent variables are measures of SES including:

- Ethnicity (Han vs. Minority Chinese)
- Education Level – the majority of those in the sample have zero years of education so we divided education level into three categories – those with no education, those with some elementary school, and those with middle school or higher education. A large literature indicates that education is a strong predictor of SES in adult life. Studies of Chinese samples report a significant correlation between education and broader measures of SES (Zhu and Xie 2007).
- Rural/Urban residence. In China, there is a large disparity between rural and urban residents, and residence is often used as a proxy for socio-economic status. Urban Chinese tend to have higher incomes, higher standards of living, and better healthcare. In addition, rural and urban status is inflexible and movement is controlled by the household registration system (*hukou*).
- Agriculture Occupation (vs. all others)
- Self-rated economic status in comparison with neighbors

We also include controls for age, gender, and marital status. Age is divided into 5 groups, 60-69, 70-79, 80-89, 90-99, and persons over the age of 100. Age is split into groups in order to better capture differences in health by age. Marital status includes widowed, married, and divorced individuals. Table 2b provides information about the independent variables.

---Table 2b---

Statistical Methods

Logistic regression analysis is used to predict dichotomous indicators of biomarkers of CVD risk and one ordinal variable (number of biomarkers), looking at the effect of our key independent variables (SES) while controlling for demographic factors.

RESULTS

Table 3 presents logistic regression equations that separately predict each of the five key dichotomous indicators of cardiovascular disease risk. In predicting a high cholesterol ratio, the only significant coefficient is for age, showing that nonagenarians are less likely to have a high cholesterol ratio than centenarians. For high blood pressure, poor self-rated economic status predicts greater odds of having high blood pressure. This finding is similar to what is seen in the west – people with lower SES have worse cardiovascular health. With regard to demographic factors, older adults in their 70's and 80's are more likely to have high blood pressure than centenarians. For the third biomarker of CVD risk, high abdominal girth, none of the SES measures are significant. However, younger elderly are again less healthy, with septuagenarians being more likely to have high abdominal girth. There are also major differences by gender, with women being nearly 7 times more likely to have large waists than men. Married individuals are also more likely to have high abdominal girth, controlling for other factors.

---Table 3---

For the fourth biomarker of CVD risk, diabetes as measured by glycosolated hemoglobin, rural residence (lower SES) increases the odds of having diabetes by 81.5% after controlling for demographic factors. In addition, there are major age effects, with younger elderly being more likely to have this risk factor than centenarians. In addition, women are less likely to have diabetes, controlling for other SES and demographic factors. For the final risk factor, high triglycerides, the results are mixed, with high education and agricultural occupation predicting worse health, and rural residence predicting better health, net of controls. That higher SES (more education) predicts worse health (high triglycerides) is the opposite of the SES-health gradient that exists in developed, Western countries but there is some evidence that this gradient is reversed in developing countries (Rosero-Bixby and Dow 2009). One possibility is that education has played a different role in the history of China. High education and high SES were not always treated favorably in the communist state. Although high education predicts worse health, the coefficients for rural residence and agricultural occupation are in the opposite direction -- i.e., rural residence predicts better health, but agricultural occupation predicts worse health. Additionally, younger elderly are more likely than centenarians to exhibit high triglycerides, but nonagenarians are less likely. Women are also more likely to have high triglycerides than men, controlling for other factors.

Table 4 presents the results from the binary logistic regression models predicting one or more, two or more, or three or more risk factors (of the five in Table 3). In addition, ordinal logistic regression was used to predict numbers of risk factors. The final dependent variable is the presence of metabolic syndrome. Some SES factors cut across multiple dependent variables. Middle school education (as compared with no education) predicts worse health in four out of the five models; the exception is the equation predicting three or more risk factors (N=112). Low self-rated economic status significantly predicts two or more, three or more, or each additional CVD risk factor (ordinal logistic regression). Age is consistent with the previous findings, younger elderly, in comparison to centenarians, are more likely to have additional risk factors and metabolic syndrome.

---Table 4---

CONCLUSION

Our findings as to the relationship between SES and risk factors of cardiovascular disease are mixed. Our inconsistent results may be due to a number of factors. First, it is not clear conceptually or empirically how socioeconomic status can best be measured in China. We relied on indicators used in past research in China and that are appropriate in developed countries, but are not confident that they are equally meaningful in China – especially among the oldest-old. Until the meaning and measurement of SES in China is clarified, conclusions about its relationships with cardiovascular risk factors remain contradictory and cannot be adjudicated. Similarly, much prior research does not show a clear SES-health gradient among adults in developing countries. This issue also cannot be resolved until valid SES indicators have been established.

The relationships between age and the cardiovascular risk factors are the strongest and most consistent results. The "young-old" were consistently more likely to have cardiovascular risk factors than the "oldest-old," especially the centenarians. This is undoubtedly the result of selective survival. Those older adults who survive to the century mark and beyond are highly elite – not only in terms of survival, but also with regard to the risk factors that threaten it.

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Table 1: Distribution by Age and Gender

Age Group	Males	Females	Total
60-69	117	76	193
70-79	111	78	189
80-89	160	155	315
90-99	109	230	339
100+	67	299	366
Total	564	838	1,402

Table 2a: Proportion of Sample with Dichotomous Indicator of Biomarker of CVD

	yes	N	no	N
High Cholesterol Ratio	0.067	94	0.933	1308
	0.00668		0.00668	
High Blood Pressure	0.143	200	0.857	1202
	0.00936		0.00936	
High Abdominal Girth	0.24	336	0.76	1066
	0.0114		0.0114	
Diabetes measured by glycosolated hemoglobin	0.336	471	0.664	931
	0.0126		0.0126	
High Triglycerides	0.175	245	0.825	1157
	0.0101		0.0101	
Metabolic Syndrome	0.121	170	0.879	1232
	0.0087		0.0087	

Standard errors in second row

Table 2b: Mean number of risk factors, stratified by independent variables

		Mean number of risk factors	N
Ethnicity	Han	0.9590	1380
		0.0270	
	Non-Han	1.0450	22
		0.1800	
Education	None	0.8540	955
		0.0312	
	Primary	1.1120	196
		0.0740	
	Middle School	1.2470	251
		0.0657	
Residence	Urban	1.0380	1031
		0.0550	
	Rural	0.9330	371
		0.0304	
Occupation	Non-Agricultural	1.0840	1200
		0.0775	
	Agricultural	0.9400	202
		0.0283	
Self-Rated Economic Status	Rich	1.0060	168
		0.0781	
	So-so	0.9290	888
		0.0328	
	Poor	1.0230	341
		0.0571	
Age Group	60-69	1.3368	193
		0.0755	
	70-79	1.2698	189
		0.0734	
	80-89	1.0444	315
		0.0504	
	90-99	0.7227	339
		0.0491	
	100+	0.7514	366
		0.0541	
Gender	Female	0.911	838
		0.0351	
	Male	1.035	564
		0.041	
Marital Status	Widowed	0.855	876
		0.0333	
	Married	1.151	511
		0.0443	

	Divorced	0.667	15
Standard errors in second row		0.232	

Table 3: Predicting Biomarkers of Cardiovascular Disease Risk by SES

	1	2	3	4	5
	High Cholesterol Ratio	High Blood Pressure	High Abdominal Girth	Diabetes	High Triglycerides
Minority Ethnicity (non-Han)	0.562	2.003	1.362	0.758	0.518
	0.587	1.004	0.692	0.392	0.351
Primary School	1.562	1.255	0.961	0.889	2.320***
	0.54	0.305	0.238	0.171	0.55
Middle School+	1.384	1.05	1.626*	1.174	2.448***
	0.502	0.271	0.384	0.226	0.591
Rural Residence	0.968	1.381	1.292	1.815***	0.180***
	0.244	0.269	0.206	0.274	0.0296
Agricultural Occupation	0.595	0.845	0.721	1.087	1.587*
	0.174	0.198	0.146	0.203	0.356
Rich self-rated economic status	1.256	1.577	1.362	0.883	1.179
	0.405	0.372	0.279	0.177	0.285
Poor self-rated economic status	1.491	1.771**	1.289	1.143	1.104
	0.377	0.314	0.203	0.168	0.22
60-69	1.016	1.725	1.614	3.127***	1.869*
	0.398	0.532	0.416	0.717	0.532
70-79	0.684	2.013*	1.844**	2.888***	2.011*
	0.271	0.558	0.437	0.62	0.557
80-89	0.74	1.611*	1.246	1.595*	2.225***
	0.231	0.389	0.25	0.298	0.525
90-99	0.468*	1.457	1.114	1.057	0.402**

	0.154	0.34	0.208	0.199	0.118
Female	1.105	0.86	6.956***	0.371***	1.485*
	0.304	0.164	1.376	0.054	0.29
Married	0.665	0.698	1.566*	1.036	1.32
	0.191	0.138	0.275	0.156	0.252
Divorced	1.874	1.738		0.213	1.07
	1.494	1.091		0.171	0.854
Chi-Square	17.13	31.28	142.3	191.5	229.8
N	1397	1397	1382	1397	1397

Exponentiated coefficients; Standard errors in second row

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] diabetes as measured by glycosolated hemoglobin; b- compared with no education; c- compared with so-so; d- compared to centenarians; e-compared to widowed.

Table 4: Predicting Number of Risk Factors and Metabolic Syndrome by SES

	One or more risk factors	Two or more risk factors	Three or more risk factors	Number of Risk Factors	Metabolic Syndrome
Minority Ethnicity (non-Han)	1.465	1.013	0.387	1.157	1.898
	0.733	0.517	0.406	0.449	1.09
Primary School[b]	1.1	1.622*	1.37	1.301	1.146
	0.212	0.333	0.439	0.214	0.336
Middle School+[b]	1.485*	1.875**	1.42	1.622**	1.940*
	0.297	0.387	0.46	0.265	0.542
Rural Residence	0.982	0.813	0.743	0.888	0.952
	0.134	0.121	0.167	0.103	0.189
Agricultural Occupation	1.064	1.065	0.781	1.038	0.943
	0.19	0.205	0.217	0.157	0.243
Rich self-rated economic status[c]	1.319	1.181	1.634	1.259	1.141
	0.243	0.245	0.477	0.199	0.317
Poor self-rated economic status [c]	1.27	1.441*	1.732*	1.333*	1.17
	0.177	0.224	0.406	0.162	0.244
60-69[d]	3.223***	2.318***	1.887	3.031***	3.576***
	0.747	0.551	0.671	0.587	1.186
70-79 [d]	3.430***	2.523***	1.439	3.163***	5.161***
	0.741	0.564	0.493	0.581	1.58
80-89 [d]	2.818***	1.357	0.97	2.176***	2.473**
	0.485	0.273	0.295	0.332	0.706

90-99 [d]	1.189	0.739	0.561	1.051	1.365
	0.183	0.155	0.183	0.155	0.402
Female	1.106	1.471*	1.162	1.274	5.537***
	0.16	0.24	0.292	0.161	1.326
Married [e]	1.151	1.169	0.743	1.134	1.609*
	0.172	0.189	0.191	0.143	0.344
Divorced [e]	0.643	0.592	0.786	0.658	
	0.356	0.466	0.836	0.334	
Chi-Square	115.8	89.76	25.26	132.4	105.6
N	1397	1397	1397	1397	1382

Exponentiated coefficients; Standard errors in second row

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

b- compared with no education; c- compared with so-so; d- compared to centenarians; e-compared to widowed.