Sociology & Anthropology Faculty Publications

Sociology & Anthropology

2017

Incorporating biomarkers into the study of socioeconomic status and health among older adults in china

Melanie S. Brasher
University of Rhode Island, mbrasher@uri.edu

Linda K. George

See next page for additional authors

Follow this and additional works at: https://digitalcommons.uri.edu/soc_facpubs

Authors

Melanie S. Brasher, Linda K. George, Xiaoming Shi, Zhaoxue Yin, and Zeng Yi

Author's Accepted Manuscript

Incorporating biomarkers into the study of socio-economic status and health among older adults in china

Melanie Sereny Brasher, Linda K. George, Xiaoming Shi, Zhaoxue Yin, Zeng Yi

Cite this article as: Melanie Sereny Brasher, Linda K. George, Xiaoming Shi, Zhaoxue Yin and Zeng Yi, Incorporating biomarkers into the study of socio-economic status and health among older adults in china, *SSM - Population Health,* http://dx.doi.org/10.1016/j.ssmph.2017.07.003

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting galley proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Incorporating biomarkers into the study of socio-economic status and health among older adults in China

Melanie Sereny Brasher [1*,] Linda K. George [2,] Xiaoming Shi [3,] Zhaoxue Yin [4], Zeng, Yi [2, 5]

[1] University of Rhode Island, Department of Sociology and Anthropology/Department of Human Development and Family Studies, 10 Chaffee Rd, Kingston, RI, USA. mbrasher@uri.edu

[2] Duke University, Department of Sociology, 417 Chapel Dr. Durham, NC 27708; Center for the Study of Aging and Human Development and the Geriatric Division of School of Medicine, Duke University, Durham, North Carolina.

[3] Institute of Environmental Health and Related Product Safety, Chinese Center for Disease Control and Prevention, Beijing, China.

[4] Division of Non-communicable Diseases Control and Community Health, Chinese Center for Disease Control and Prevention, Beijing, China

[5] Center for Healthy Aging and Development Studies, National School of Development, Raissun Institute for Advanced Studies, Peking University, Beijing, China.

* Corresponding author

Introduction

Social and medical scientists have long been interested in examining the relationship between socioeconomic status (SES) and health. Individuals with lower SES experience higher mortality risks, disease, and deleterious health conditions. This "social gradient" in health has been observed across multiple time periods and age groups, using a wide range of SES indicators, health measures, and methodologies (Adler & Stewart 2010; Elo 2009; Goldman 2001). While we have considerable evidence on the SES-health relationship using self-reports of health in Western, industrialized countries, less is known about the SES-health relationship using

1

biological indicators ("biomarkers") in less developed countries, such as China. In addition, limited research has investigated how age interacts with the social gradient in health, it is not yet clear whether SES disparities grow wider or narrower in later life.

Our study examines SES and health among older adults living in rural regions of China. The People's Republic of China (PRC) is an important context to study because of dramatic demographic, economic, social, and health changes in recent decades. Comprising approximately twenty percent of the world's population, the country is experiencing rapid population aging. As China has gained greater control over infectious disease and undernutrition, chronic diseases are now the major causes of mortality. China has also undergone geographically uneven socioeconomic development. While the quick pace of economic growth in the 1990s and 2000s has resulted in an overall increase in the standard of living -- "a rising tide lifts all boats" (Treiman 2012), there are growing disparities between rural and urban areas and between interior and coastal provinces. Particularly in rural areas, many Chinese elderly lack access to health care, which may mean that self-reports of health are inaccurate.

Incorporating biomarkers into research on the social gradient in health in lower and middle-income countries is important because rapid population aging will lead to an increase in the health-related needs of older adults with limited economic resources. Biomarkers can give us objective assessments of underlying risk factors for disease. This is of particular importance in rural populations with limited access to health care, where under-diagnosis of chronic disease is common.

2

This study contributes to our understanding of the relationship between socioeconomic status and health in the developing world, by studying biological health indicators for older adults residing in rural China. Our study makes several contributions. First, it compares SES differences in health across individual biomarkers and composite measures, as well as more traditional self-reports of health. Most datasets contain fewer biomarkers than are available in this study. We also examine how the SES-health relationship interacts with age, an under-studied topic. In addition, our focus on rural China and examining risk factors for obesity and cardiovascular disease will contribute to our understanding of where China is in its epidemiological transition.

The purpose of this study is to examine the relationship between SES and health among older adults in rural longevity areas of China. We use data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) longevity areas, with respondents ages 60 to 100+. In examining both biomarkers and self-reports of health we pose the following questions: Is higher SES associated with better health (positive relationship) among rural Chinese elderly? Does the SES-health relationship vary by type of health measure? Which SES measure (education or occupation) is more predictive? How does the SES-health relationship differ between the young-old (ages 60-79) and oldest-old (80+)?

3

1. *Background*

2.1 Social Gradient

Socioeconomic status is a fundamental cause of disease (Link & Phelan, 1995). SES determines access to important resources and influences multiple health outcomes through various mechanisms. Socioeconomic status and health are linked through both material and non-material mechanisms. For the former, greater economic resources allow access to better nutrition, housing, and healthcare and result in less exposure to environmental hazards. Non-material pathways include social-psychological resources such as better health behaviors (Lantz et al. 1998; Ross and Wu 1995), lower exposure to stress (Lantz et al. 2005), greater personal control (Taylor & Seeman 1999), and increased health knowledge (Goldman & Smith 2002). In addition, associations with health remain important even when interceding mechanisms change (Link & Phelan 1995).

An abundant body of literature documents a gradient between socioeconomic status (SES) and health (Adler et al. 1994; House, Kessler, & Herzog 1990; Marmot et al. 1991; Mirowsky & Ross 2001; Wilkinson & Pickett 2006). Most of this research has been conducted in Western, developed countries and corroborates a positive association – higher SES is correlated with better health. There is still debate, however, regarding the consistency and direction of the gradient in developing countries (Bahonar et al 2011; Rosero-Bixby & Dow, 2009; Mceniry, 2013; Monteiro et al., 2004; Smith & Goldman 2007; Zimmer, Chayovan, Lin, & Natividad, 2004).

4

There are several possible explanations for why the social gradient may be weaker or even reversed in less developed countries. One, development takes place unequally across regions of a country, and so does progress in the epidemiologic health transition from infectious disease to chronic disease. In addition, different population groups vary in exposure to health-enhancing (good diet, exercise, etc.) or health-damaging (smoking, drinking, etc.) factors. When looking at average relationships, SES-related health inequalities may not be visible in a society where one group has a positive relationship and another has a negative relationship

While the social gradient for mortality, general health, and disability is well documented, the connection between SES and biomarker measures is less clear-cut. This is partly because only recently have biomarker measures been added to population surveys. In a review of the literature on studies from more developed countries, Kavanagh and colleagues (2010) found evidence that low SES was associated with a poorer biomarker profile. It may be that lower SES individuals exhibit worse biomarker profiles because of greater "wear and tear" on the body's regulatory systems (Seeman, Epel, Gruenewalk, Marlamangla, & McEwen, 2010). For more information on commonly studied biomarkers and the physiological processes and health consequences refer to Turra et al (2005) and Seeman et al (2010). Importantly, however, previous research demonstrates that the associations vary by specific biomarker and measures of SES. For example, research from some European populations found that the social gradient for hypertension was relatively small compared to other biomarkers (Bobak et al 1999; Hotchkiss et al, 2012).

It is also important to study biomarkers in developing country settings to get a sense of where a country is in its epidemiological transition (Monteiro et al 2004). For example, are high SES or low SES people more likely to have unhealthy lifestyles, be obese, or exhibit risk factors for cardiovascular disease? Monteiro and colleagues (2004) found that a positive relationship between SES and health – such as lower SES people being more likely to exhibit obesity – was occurring earlier in economic development for many less developed countries. This seemed to be particularly common among women. For additional biomarker measures beyond obesity, Rosero-Bixby and Dow (2009) found an erratic and weaker relationship between SES and health than that found in wealthier countries. Biomarkers are important to measure because when health services are not available to lower-income individuals, only high SES individuals will have access to medication facilities and be more self-aware of health conditions (Zimmer & Kwong, 2004).

How the social gradient in health changes in older adulthood in an under-studied topic. Previous research often distinguishes between the age-as-leveler hypothesis (House, Lantz, and Herd, 2005; House et al. 1994) and cumulative dis/advantage theory (O'Rand, 2003). The former theory posits that health inequalities increase over the adult years, but then decrease in older adulthood. Convergence of the social gradient could be due to selective mortality – mortality eliminates frail low-income individuals (Crimmins, 2005). Alternatively, old-age social welfare programs may bridge the gap in resources and access to care. Cumulative dis/advantage theory provides support for a widening of disparities. Specifically, earlier and on-going disadvantages in SES accrue over time, leading to high levels of late-life inequality. For higher-SES individuals,

6

the protective effects accumulate with age, giving further advantage to high status individuals as the life course progresses (Kim & Durden, 2007; O'Rand, 2003; Ross & Wu 1996).

A few studies of older Americans have found support for the age-as-leveler hypothesis (Herd 2006; Minkler, Fuller-Thomson & Guralnik, 2006). A recent study which examined joint trajectories of physical, emotional, and cognitive functioning also found that the education-health gradient converged in later old age (Xu et al 2014). They also found that while education mattered for onset of health problems, income mattered more for progression of health problems. Distinguishing between different health and SES measures, Kim and Dureden (2007), by contrast, found that the gaps between education/income and physical impairment, and between education and depression diverged over time (cumulative disadvantage). For income and depression however, they found support for the age-as-leveler hypothesis.

2.2 Chinese Context

China is an important and unique context for examining the social gradient among older adults. The country is undergoing rapid population aging, and has the greatest number of oldest-old adults in the world according to United Nations data. Along with rapid demographic, economic, and social change in past decades, China is undergoing an epidemiological transition moving from the primacy of acute infectious and deficiency diseases to the increasing dominance of non-communicable and chronic conditions that are generally associated with older populations.

SES differentials in health are also impacted by healthcare systems. After economic reforms began in China (in the late 1970s), the country shifted from public provision of healthcare toward a market system of health care financing and delivery, although many hospitals continue to be run by the state. The majority of rural citizens do not have health insurance and the market cost for health care can be prohibitively expensive (Hu et al., 2008; Zhao, 2006). New efforts to improve rural health care resulted in the launch of the New Cooperative Medical System (NCMS) in 2003, but reimbursement rates are low and catastrophic illness can still cause Chinese families to plunge into poverty (You & Kobayashi, 2009). In a country with few social safety nets, economic resources are important for health.

Previous research from China on the social gradient in health has mixed results – positive, negative, and no association. Several studies have found negative associations between SES and health, i.e. higher SES and worse health. This has included poor health behaviors (Du et al., 2004), obesity (Strauss et al., 2010), hypertension (Lei et al., 2014), and cardiovascular disease (Zimmer & Kwong, 2004). These negative associations could be due to increased health risks from poor health behaviors associated with higher SES individuals, such as smoking, alcohol consumption, and rich diet. By contrast, Gu and Zeng's study using the CLHLS data (2004), found no association between education and disability levels. A good deal of studies have confirmed SES differences in health, particularly for mortality – higher SES, lower probability of death (Liang, Liu & Gu, 2001; Zhu & Xie, 2007). Other research has also found a positive association for cognitive impairment (Zhang, Gu & Hayward, 2010), self-rated health (Lei et al., 2014; Li & Xu, 2008; Liu et al., 2007; Wu et al., 2004), and functional limitations (Beydoun &

8

Popkin, 2005) among older adults. Socio-economic status was also associated with greater

access to care. Rural older people were less likely to visit doctors and clinics than urban residents

(He, 2007).

As our present study focuses on rural China, we are particularly interested in previous

China studies of rural populations. Prior research that examined the interaction between SES and

residence (rural vs. urban) found that education had a stronger impact on rural residents in terms

of self-rated health (Lei et al 2014) and functional limitations (Zimmer et al 2010). By contrast,

education's effect was stronger in urban areas in reducing ADL/IADL disability, hypertension

(Lei et al 2014), and mortality among the oldest-old (Zhu & Xie, 2007). Other research which

examined rural/urban hukou as a predictor of health found that among the oldest-old, urban

respondents were more likely than rural respondents to have an ADL disability, but no

differences for self-rated health (Zeng et al 2007). Similarly, Wen and Gu's (2011) examination

of community SES found living in a more developed community was associated with ADL

disability. Previous research on residence and mortality found mixed results – lower mortality for

urban residents (Luo, Zhang, & Gu 2015) and no difference (Luo & Xie, 2014).

Many studies have utilized the CLHLS data to study the oldest-old, but very few studies

look at age group sub-samples or age-by-SES interactions in China. One exception is a recent

study which focused on mechanisms that underlie the connection between education and

mortality. Luo, Zhang, and Gu (2015) found that the effect of education on mortality was weaker

among the oldest-old than young-old. This provided evidence for the age-as-leveler

(convergence) hypothesis. Another study which studied both biomarkers and self-reports of

9

health did not look at age interactions but did compare older elderly (75+) to younger respondents. Net of controls (including SES), Strauss and colleagues (2010) found that older people had higher BMI and greater risk of hypertension.

Education, occupation, income, and wealth are frequently used measures of SES in studies of the social gradient in more developed countries. In studies of older Chinese, however, it is not yet clear which metrics are the most appropriate. Recent research on the social gradient in health among older adults in China has used the following measures of SES: education (Luo, Zhang, & Gu, 2015; Luo & Xie, 2014; Wen & Gu, 2011; Xu & Xie, 2016), occupation (Lao et al. 2015; Luo, Zhang, & Gu, 2015; Wen & Gu, 2011), economic independence (Luo, Zhang, & Gu, 2015; Luo & Xie, 2014; Wen & Gu, 2011), wealth, party membership (Xu & Xie, 2016), good economic status, and access to healthcare (Wen & Gu, 2011). Three recent studies also examine household income, but their samples also include middle-aged respondents (Chen, Yang, & Liu, 2010; Luo & Xie, 2014; Xu & Xie, 2016).

Studies have also highlighted that various SES measures may be differentially associated with health outcomes. For example, Lei et al. (2014) found that those with more education were less likely to be disabled, but those with higher per capita expenditures were more likely to be disabled. In addition, work by Wen and Gu (2011) found that childhood SES exerts long-term effects on functional limitations, cognitive impairment, self-rated health, and mortality in addition to adult and community SES and psychosocial factors.

3. *Data and Methods*

3.1 Data

This study uses data from respondents who resided in longevity areas in China interviewed in 2008-09 and 2012 during the fifth and sixth waves of the CLHLS. The survey began in 1998 and follow-up surveys with replacement for deceased elderly have been carried out every two or three years. The survey attempted to interview all centenarians, as well as one nearby nonagenarian, octogenarian, and younger elderly (60-79) of pre-designated age and sex. Respondents provided extensive data on demographic characteristics, family and household characteristics, socioeconomic status, social support, self-rated health, and activities of daily living. More detail on the study design can be found elsewhere (Zeng et al., 2002). In order to learn more about the health status of respondents, additional older adults residing in "longevity areas" in China were surveyed in 2009 and 2012 and blood and urine samples were collected and analyzed.

"Longevity areas" are counties and city districts that have been designated as such by the Chinese Association of Gerontology in accordance with 15 criteria. Three of the most important indicators of the longevity designation are: more than 7 centenarians per 100,000 population, those aged 80 and older make up at least 1.4% of the population, and the average life expectancy in the area is at least 3 years higher than the national average. The 2009 survey was conducted in seven longevity areas in China: Xiayi County in Henan Province, Zhongxiang City in Hubei Province, Mayang County in Hunan Province, Yongfu County in Guangxi Province, Laizhou

11

City in Shandong province, and Chengmai County in Hainan Province, and Sanshui District (Foshan City) in Guangdong Province. These areas are geographically diverse, including locales from northern, central, and southern regions of China. In 2012, researchers returned to these areas, and re-interviewed respondents, as well as added more participants from the seven areas and added 1 additional area – Rudong county in Jiangsu province. For our present study, we focused on rural areas and excluded respondents from Sanshui district, Foshan city.

Data were collected through face-to-face survey interviews, in-home physical examinations, and collection of biological specimens by medical personnel. A physical examination measured blood pressure, height, waist circumference, and vision. Willing participants provided 5 milliliters of venous blood and 15 milliliters of urine after an overnight fast of at least 12 hours. Plasma lipids/lipoproteins (TC, TG, HDL, LDL), high sensitivity C-reactive protein (hs-CRP), and fasting plasma glucose (FPG) were measured by an Automatic Biochemistry Analyzer (Hitachi 7180, Japan) using commercially available diagnostic kits (Roche Diagnostic, Mannheim, Germany). All laboratory analyses were conducted by the central clinical lab at Capital Medical University in Beijing.

This paper uses survey and biomarker data from the fifth (2008-09) and sixth (2012) waves of the CLHLS. We did this in order to make use of two waves of data and increase statistical power. Although we analyzed 2 waves of data, we only analyzed one data point per respondent. We used the 2009 measure for respondents that were in both waves, and 2012 data for newly added respondents.

There were 2,181 elderly subjects from the 2008-2009 CLHLS who resided in 8 longevity areas. In addition, 1,340 elderly respondents were newly recruited in 2012. Of that total sample size of 3,521, we limited analysis to respondents who are over age 60, provided blood samples, lived in rural areas, and answered questions pertaining to key covariates. Our final analytical sample is 2,121. 750 are young-old and 1,371 are oldest-old. In comparing the full sample to the analytical sample, we found similar scores for gender, marital status, health insurance, and education. A lower proportion of the analytical sample worked in non-agricultural occupations, this is partly due to excluding urban hukou holders.

3.2 Measures

3.2.1 Health. Health indicators include individual biomarkers of cardiovascular disease/ metabolic function, composite measures, and self-reports of health. The individual biomarker variables included in this paper are blood pressure, total cholesterol, HDL cholesterol, cholesterol ratio (HDL to total cholesterol), triglycerides, fasting glucose, C-reactive protein, waist circumference, and body mass index[1] (BMI). The two composite indicators are metabolic syndrome and cumulative risk factors. Metabolic syndrome is defined as having high abdominal girth and at least two of the following risk factors: diabetes, high triglycerides, low HDL cholesterol, and hypertension (International Diabetes Foundation; Rosero-Bixby & Dow, 2009). The cumulative risk factor is a tally of cardiovascular disease risk factors including high waist

---

[1] The BMI cut-off values are those suggested by a WHO expert who compared how BMI values differ between Asian and European populations (Nishida et al 2004).

circumference, diabetes, hypertension, high triglycerides, and high cholesterol ratio. Cumulative risk may be a better indicator than clinical outcomes, because it focuses on multiple pathways that may lead to cardiovascular disease (Goodman et al., 2005). The composite measures include both biomarkers and diagnosed chronic diseases.

In regression analysis, the individual biomarker variables are treated as binary variables where 1 is above the clinical cut-point and 0 is below. Table 1 provides the cut-off points for each individual biomarker[2]. Most of the measures in this analysis have well-established cut-off points (Goldman et al. 2011). Metabolic syndrome is also a binary variable, where 1 is presence of metabolic syndrome and 0 is absence. Cumulative risk is both a binary and a count variable. It comprises three binary variables – 1 or more, 2 or more, and 3 or more risk factors.

General health outcomes assessed from survey data include self-rated health (SRH), activities of daily living limitations (ADL), instrumental activities of daily living (IADL), and functional limitations. Self-rated health was assessed by asking respondents, "In general, would you say your health is: (1) very good, (2) good, (3) fair, (4) bad, or (5) very bad?" The variable was reverse coded, where a 5 reflects very good and 1 very bad health. SRH was dichotomized into very good/good health (code = 1) versus fair/bad/very bad health (code = 0) and treated as a binary outcome. ADL disability is a binary variable where if a respondent needed assistance in any of the six ADL items (bathing, dressing, indoor transferring, toileting, incontinence, and eating), he or she is considered to be disabled (code = 1). IADL limitations are assessed as self-

---

[2] Diabetes (Ezeamama et al 2006; Lv et al 2015); CRP (Pearson et al, 2003).

14

reported difficulty with performing any of the following activities independently: visiting neighbors, shopping, cooking, washing clothes, and taking public transportation. IADL is assessed as a binary variable where 1 is "disabled" and 0 is "active." Similarly, functional limitations were assessed by whether the respondent can independently: walk for 1 km, lift a weight of 5kg, and continuously crouch and stand up 3 times. Functional limitation is treated as a dichotomous indicator, with 1 indicating difficulty with any of the three items and 0 indicating no difficulty.

3.2.2 Socioeconomic Status. Education, occupation, income, and wealth are frequently used measures of SES in studies of the social gradient in more developed countries. In studies of older Chinese, however, researchers do not yet agree on the most appropriate metrics of SES.

We operationalize SES as education level and former occupation (occupation held before age 60). These measures are commonly used in studies of the SES-health relationship and therefore maximize comparability with other studies (see literature review). The analyses compared high and low SES as dichotomously measured rather than a true gradient based on ordinal or continuous categories. A large literature indicates that education is a strong predictor of SES in adult life, including research from China (Zhu & Xie, 2007). To capture education, respondents were asked "How many years did you attend school?" Due to the high number of respondents who answered 0, education is treated as a binary variable with 0 indicating no formal education, and 1 indicating some. Education levels are especially low the oldest-old (see Table 1).

For occupation, respondents were asked: "What was your primary occupation before age 60?" Respondents could choose from 1) professional or technical, 2) governmental/managerial, 3) service/industrial worker, 4) self-employed, 5) agriculture/forestry/fishery, 6) housework, 7) military personnel, 8) unemployed, and 9) other. As seen in table 1, more than 80% of respondents worked in agriculture or fishing. Therefore occupation is treated as a binary variable with non-agricultural occupations coded as 1 (higher SES) and agriculture/fishing coded as 0.

Control Variables. Control variables include gender, marital status, and health insurance status. Marital status was dummy coded (married=1, unmarried, widowed=0). Health insurance was measured by a survey question which asked "Do you have basic medical insurance?" (yes=1, no=0).

3.3 Statistical Analysis

Analyses were run separately on young-old and oldest-old subsamples because we were interested in examining whether the SES-health relationship varied by age group. We also did so because age significantly interacted with several of the other variables for most of the health outcomes. For the individual biomarkers, binary logistic regression models were used to calculate the odds of being above the clinical cut-point of each biomarker. Binary logistic regressions were also used for the outcomes of metabolic syndrome; having one or more, two or more, or three or more CVD risk factors; good self-rated health; ADL disability; IADL disability; and functional limitations. For the cumulative risk score, Poisson models were used to calculate the incident rate ratios of moving one point higher. Each model includes controls for gender,

marital status, and health insurance coverage. Education and occupation were added in separate

models to avoid multicollinearity. All analyses were performed using STATA version 13.1

(StataCorp, College Station, TX).

4. Results

Table 1 presents the distributions of this paper's key independent variables and controls,

stratified by age group. A greater proportion of young-old respondents were female[3], married,

had basic health insurance, and had higher SES—education and former occupation.

Table 2 presents cut-off points and percentages above the normal levels for health

variables – both biomarkers and self-reports – separately by age group (young-old and oldest-

old). There were significant differences between younger and older respondents for most of the

health indicators. For the biomarkers, it was mixed whether the young-old or oldest-old

respondents had higher percentages at the clinical level. In this sample, a greater proportion of

young-old exhibited worse health in terms of low HDL cholesterol, high cholesterol ratio, high

triglycerides, large waist circumference, metabolic syndrome, and count of CVD risk factors.

Oldest-old respondents were more likely to present hypertension, underweight, and CRP. For

self-reports of general health, oldest-old respondents were consistently in worse health in terms

of self-rated health, ADL disability, IADL disability, and functional limitations.

---

[3] The overall CLHLS longevity areas sample has similar percentage female. The survey as a whole has

equal numbers of males and females – part of the sampling design.

Tables 3a and 3b present the estimates of the association of SES with individual biomarker measures. Young-old and oldest-old were analyzed separately. Overall 9 out of 10 biomarkers were significantly associated with SES (education, former occupation, or both) for the young-old sub-sample and 10 out of 10 for the oldest-old sub-sample. With gender, marital status, and health insurance status controlled for, higher SES was associated with better health for the vast majority of the biomarkers (odds ratio less than 1).

Both young-old and oldest-old respondents with some formal education (vs. none) were less likely to present high total cholesterol, high triglycerides, elevated CRP, low HDL, high cholesterol ratio, diabetes, obesity, and underweight. In addition, oldest-old with some education were less likely to present high waist circumference.

In a separate model with occupation as the measure of SES, both young-old and oldest-old respondents whose former occupation was not agriculture were also less likely to have high total cholesterol, high triglycerides, high cholesterol ratio, diabetes, and underweight. Additional positive relationships (higher SES, better health) were found for waist circumference, CRP, HDL, and obesity among oldest-old respondents. For both obese and underweight, there was a positive association between higher SES and better health (lower likelihood of obese/overweight). In other words, those with higher SES were more likely to be of normal weight.

Looking at both age groups, individual biomarkers had a more consistent relationship with education (9 of 10) than for occupation (5 of 9). Among the oldest-old, one additional outcome was associated with greater education (waist circumference) and three additional outcomes were associated with non-agricultural occupation – CRP, HDL, and obesity. In

18

addition, several of the odds ratios were stronger for oldest-old than young. For example, among the oldest-old, having some education reduced the odds of high triglycerides by a factor of 7.14 (1/.14), whereas for young elderly with education the odds of high triglycerides were reduced by a factor of 4.06 (1/.246).

For the individual biomarkers, the only negative relationship (high SES, worse health) was for hypertension. Young-old whose former occupation was non-agricultural were more likely to present hypertension, and oldest-old with some education were more likely to present hypertension. This may be because, unlike the other biomarkers, this was measured both by clinical measurement and self-report of ever being diagnosed with hypertension. Those older adults with higher SES likely had greater access to medical care and were more aware of having risk factors for disease, such as hypertension.

Table 4 shows the associations between SES and composite measures--metabolic syndrome and a count of CVD risk factors. We found SES to be consistently associated with these outcomes for young-old elderly. Interestingly, we found a negative relationship between SES and health for presenting 1 or more CVD risk factor and for a count of risk factors (Poisson regression). These CVD risk factors included high waist circumference, diabetes, hypertension, high triglycerides, and high cholesterol ratio. Upon further investigation, hypertension is the most common risk factor among those who present at least 1 CVD risk factor, and this may be that higher SES individuals are more likely to have that hypertension diagnosis from a doctor because of access to health care. For the other outcomes -- metabolic syndrome, two CVD risk factors, and 3 CVD risk factors – the relationship was positive (higher SES, better health). Again

19

we found the association between education and health (versus occupation) measures to be more consistent, except for the negative relationships.

For the oldest-old, the relationships were largely similar – a positive health-SES relationship for most outcomes except for having one or more CVD risk factors. Those with higher SES – measured by either education or former occupation – were likely to be protected from poor health such as metabolic syndrome or having multiple CVD risk factors.

Table 5 reports the associations between self-reports of health and SES. For both sub-samples, we found a positive relationship. Those with higher SES were less likely to have ADL disability, IADL disability, or functional limitations. There were no significant associations between SES and self-rated health. For the young-old, both education and former occupation were significantly associated with health outcomes, but for the oldest old former occupation was not significantly associated with IADL disability.

5. Discussion

Using a rich array of biomarkers and self-reports of health from the CLHLS data, this paper assesses the relationship between SES and health among young-old and oldest-old Chinese elderly living in rural longevity areas of China. For the most part we find a positive relationship between SES and health. This held for both individual biomarkers, composite measures, and disability status. Two notable exceptions are negative relationships found for hypertension and having one or more CVD risk factors. We found more significant associations between education and health for biomarkers among the young-old and for composite measures for both age groups.

Both education and occupation predicted individual biomarkers for the oldest-old and predicted self-reports for both age groups. In comparing the size and significance of odds ratios between the age groups, we found that SES was more consistently associated with individual biomarkers for the oldest-old, similar for both age groups for composite measures, and more common for the young-old for disability measures.

This study highlighted the importance of collecting biological indicators for populations with limited access to regular healthcare – such as poor, rural older adults in China. Under-diagnosis of disease is common in rural areas of developing countries (Mendez-Chacon et al, 2008). It also gives us insight into where rural China is in the epidemiological transition. Previous research on obesity and SES in China highlights the idea that China may now be at the stage that the burden of obesity has shifted from high SES to low SES individuals (Lao et al. 2015). With a broader array of biomarkers, this study also provides evidence that higher SES is associated with better health, even for risk factors of cardiovascular disease that are associated with diet and lifestyle. Rapid economic development in China may be leading to a rapid health transition as well (Lao et al 2014).

We found a consistent relationship between SES and health, even among particularly long-lived Chinese older adults who reside in longevity areas. These older adults have lived through different social, economic, and health regimes. On the one hand, the respondents in our study may have benefited from the state public health campaigns in the 1950s and 1960s, but were harmed by unequal access to health care in the most recent decades (Chen, Yang, & Liu, 2010). The average young-old respondent in our sample was 70 years old in 2009, therefore born

21

in 1939 and entered old age (60+) in 1999. The average oldest-old respondent was 92 years old, born in 1917, and entered old age in 1977. The average oldest-old respondent came of age prior to the Communist revolution and did not benefit (as a young person) from mass public health campaigns. Having not experienced greater economic equality when young may make them more sensitive to SES differentials in later life. Chen, Yang, and Liu's (2010) research on Chinese cohort differences in health trajectories found that for older cohorts additional education "purchased" better health. They also found that the cumulative disadvantage process weakened in more recent cohorts. The stronger "social gradient" for biomarkers among oldest-old respondents may also have to do with living in longevity areas. They were able to survive to advanced ages, despite socioeconomic disadvantage that leads to higher levels of risk factors for disease (biomarkers).

This also leads to questions about what is the best way to measure SES for older adults who have lived through very different social and economic circumstances. In our study we found education to be more consistently associated with good health than occupation. Sociological understandings of how education influences health includes through higher earnings, greater sense of control, and greater health knowledge. It may be that education matters more for health knowledge whereas in the Mao era, occupation was not that strong of an indicator of where you were in the social hierarchy because of low levels of socioeconomic stratification (Chen, Yang, & Liu, 2010). At present day, however, access to economic resources still matter as there are few social safety nets in China.

Our study found consistent associations between biomarkers and SES, mostly positive. This contrasts previous research from Costa Rica, another middle-income country, which found a weaker association between SES and some traditional cardiovascular risk factors than found in wealthier societies (Rosero-Bixby & Dow, 2009). Additionally, Dowd and Goldman's research from Taiwan (2006), found that less than one-fourth of biomarkers of stress and cardiovascular disease were significantly associated with SES among men. One negative association that we found was between SES and hypertension – both young-old and oldest-old respondents with higher SES were more likely to exhibit hypertension. Previous research from China found that the risk of hypertension increases with age (Strauss et al 2010). Lei and colleagues (2014) also found that having some education was associated with greater likelihood of hypertension, but only for men and urban residents. It may be that higher SES individuals have greater access to high-salt diets, leading to greater risk of hypertension (Fang et al 2015).

We found that SES was a stronger predictor of general health for the young-old than for the oldest-old. This is similar to previous research which found education's effect on mortality was weaker for the oldest-old. By contrast, our findings for individual biomarkers we found the size and significance of odds ratios to be larger among the oldest-old. This may have to do with cohort differences (see previous paragraphs). Our results indicated that there was no significant association between self-rated health and SES. This corresponds with some recent research that found adult SES was not associated with SRH (Wen & Gu, 2011) or another study that found it was only a significant relationship for females (Strauss et al 2010). This is different, however, from some other studies in China and in more developed countries. This may have something to

23

do with residing in a rural area and not having as much health knowledge to accurately self-assess health.

Several potential limitations of this study deserve attention. As our study focuses on rural older adults, it is important to note that rural people may have better health than urban residents in terms of ADL disability (Wen & Gu, 2011; Zeng et al 2002). In addition, the respondents for this study reside in longevity areas and it is not clear to what extent these respondents differ from persons living in other rural areas of China, besides their relative average longevity. In addition, cohort effects may influence the findings, and examining pooled cross-sectional data does not permit us to examine cohort differences. Conditions in China have varied dramatically over the course of the 20th century. While Mao-era China promoted a "classless" society, income inequality has increased dramatically in the decades since economic reform. We are also unable to account for selection effects – that those least healthy (and most disadvantaged) do not survive to the oldest-old ages and therefore our sample consists of only very robust individuals. Last, our study does not have measures of wealth or reliable measures of household income, making it difficult to compare to some previous research.

While this study has added to our understanding of SES differentials in health among older adults in a rural, developing country setting, there are many avenues for future research. China is a particularly interesting context because of geographically uneven socioeconomic development. Future research should investigate SES-health differences by cohort among the oldest-old and how best to operationalize SES and biomarkers among older Chinese. In addition,

more comparative research in developing countries could shed light on whether SES-health disparities diverge or converge in later life.

This study highlights the importance of collecting biological indicators for populations with limited access to regular healthcare – such as poor, rural older adults in China. Under-diagnosis of disease is common in rural areas of developing countries (Mendez-Chacon et al, 2008). Additionally, our research can give us a greater understanding of China's progress in its health and nutrition transition. The inclusion of biological and anthropometric measures of health in this and other surveys expands the possibilities for social scientists to elucidate the mechanisms between social experiences and health outcomes. While other surveys collect data on a limited number of biomarkers, our extensive data permitted us to examine SES and health using a broad array of biological factors, acknowledging that there are multiple pathways by which SES "gets under the skin". As China's economy develops and the standard of living rises, researchers will have the opportunity to see whether the SES-health gradient will change, and whether individuals and communities will become more or less heterogeneous in terms of the association between socioeconomic status and health.

Authors Declaration

Acknowledgements

25

References

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., & Syme, S. L. (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist, 49*(1), 15.

Adler, N. E., & Stewart, J. (2010). Health disparities across the lifespan: Meaning, methods, and mechanisms. *Annals of the New York Academy of Sciences, 1186*(1), 5–23.

Bahonar, A., Sarrafzadegan, N., Kelishadi, R., Shirani, S., Ramezani, M. A., Taghdisi, M. H., & Gharipour, M. (2011). Association of socioeconomic profiles with cardiovascular risk factors in Iran: The Isfahan healthy heart program. *International Journal of Public Health, 56*(1), 37–44.

Beydoun, M. A., & Popkin, B. M. (2005). The impact of socio-economic factors on functional status decline among community-dwelling older adults in china. *Social Science & Medicine, 60*(9), 2045–2057.

Bobak, M., Hertzman, C., Skodova, Z., & Marmot, M. (1999). Socioeconomic status and cardiovascular risk factors in the Czech Republic. *International Journal of Epidemiology, 28*(1), 46–52.

Chen, F., Yang, Y., & Liu, G. (2010). Social change and socioeconomic disparities in health over the life course in China a cohort analysis. *American sociological review, 75*(1), 126–150.

Crimmins, E. M., Kim, J. K., & Seeman, T. E. (2009). Poverty and biological risk: The earlier "aging" of the poor. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 64*(2), 286-292. doi:10.1093/gerona/gln010 [doi]

Diez Roux, A. V. (2012). Conceptual approaches to the study of health disparities. *Annual Review of Public Health, 33*, 41-58. doi:10.1146/annurev-publhealth-031811-124534 [doi]

Dowd, J. B., & Goldman, N. (2006). Do biomarkers of stress mediate the relation between socioeconomic status and health? *Journal of Epidemiology and Community Health, 60*(7), 633-639. doi:60/7/633 [pii]

Du, S., Mroz, T. A., Zhai, F., & Popkin, B. M. (2004). Rapid income growth adversely affects diet quality in China—particularly for the poor!. *Social science & medicine, 59*(7), 1505-1515.

Elo, I. T. (2009). Social class differentials in health and mortality: Patterns and explanations in comparative perspective. *Annual Review of Sociology, 35*, 553-572.

Ezeamama, A. E., Viali, S., Tuitele, J., & McGarvey, S. T. (2006). The influence of socioeconomic factors on cardiovascular disease risk factors in the context of economic development in the Samoan archipelago. *Social Science & Medicine, 63*(10), 2533-2545.

Farrell, L., Hollingsworth, B., Propper, C., & Shields, M. A. (2014). The socioeconomic gradient in physical inactivity: Evidence from one million adults in England. *Social Science & Medicine, 123*(0), 55-63. doi:http://dx.doi.org.uri.idm.oclc.org/10.1016/j.socscimed.2014.10.039

Goldman, N. (2001). Social inequalities in health. *Annals of the New York Academy of Sciences, 954*(1), 118-139.

Goldman, N., Turra, C. M., Rosero-Bixby, L., Weir, D., & Crimmins, E. (2011). Do biological measures mediate the relationship between education and health: A comparative study. *Social science & medicine, 72*(2), 307-315.

27

Gu, D., & Zeng, Y. (2004). Sociodemographic effects on the onset and recovery of ADL disability among Chinese oldest-old. *Demographic Research, 11*(1), 1-42.

He, W. (2007). *Health and health care of the older population in urban and rural china: 2000* US Census Bureau.

Herd, P. (2006). Do functional health inequalities decrease in old age? Educational status and functional decline among the 1931-1941 birth cohort. *Research on Aging, 28*(3), 375-392.

Hotchkiss, J. W., Davies, C. A., Gray, L., Bromley, C., Capewell, S., & Leyland, A. (2012). Trends in cardiovascular disease biomarkers and their socioeconomic patterning among adults in the Scottish population 1995 to 2009: Cross-sectional surveys. *BMJ Open, 2*(3), 10.1136/bmjopen-2011-000771. Print 2012. doi:10.1136/bmjopen-2011-000771 [doi]

House, J. S., Lepkowski, J. M., Kinney, A. M., Mero, R. P., Kessler, R. C., & Herzog, A. R. (1994). The social stratification of aging and health. *Journal of Health and Social Behavior*, 213-234.

House, J. S., Lantz, P. M., & Herd, P. (2005). Continuity and change in the social stratification of aging and health over the life course: evidence from a nationally representative longitudinal study from 1986 to 2001/2002 (Americans' Changing Lives Study). *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *60*(Special Issue 2), S15-S26.

Hu, S., Tang, S., Liu, Y., Zhao, Y., Escobar, M., & de Ferranti, D. (2008). Reform of how health care is paid for in china: Challenges and opportunities. *The Lancet, 372*(9652), 1846-1853.

Huang, W., Lei, X., Ridder, G., Strauss, J., & Zhao, Y. (2013). Health, height, height shrinkage, and SES at older ages: Evidence from china. *American Economic Journal: Applied Economics, 5*(2), 86-121.

Huisman, M., Kunst, A. E., Andersen, O., Bopp, M., Borgan, J. K., Borrell, C., Mackenbach, J. P. (2004). Socioeconomic inequalities in mortality among elderly people in 11 European populations. *Journal of Epidemiology and Community Health, 58*(6), 468-475.

Kavanagh, A., Bentley, R. J., Turrell, G., Shaw, J., Dunstan, D., & Subramanian, S. (2010). Socioeconomic position, gender, health behaviours and biomarkers of cardiovascular disease and diabetes. *Social Science & Medicine, 71*(6), 1150-1160.

Kim, J., & Durden, E. (2007). Socioeconomic status and age trajectories of health. *Social Science & Medicine, 65*(12), 2489-2502.

Kohler, I. V., Soldo, B. J., Anglewicz, P., Chilima, B., & Kohler, H. (2013). Association of blood lipids, creatinine, albumin, and CRP with socioeconomic status in Malawi. *Population Health Metrics, 11*(1), 1.

Kunst, A. E., Groenhof, F., Mackenbach, J. P., & Health, E. W. (1998). Occupational class and cause specific mortality in middle aged men in 11 European countries: Comparison of population based studies. EU working group on socioeconomic inequalities in health. *BMJ (Clinical Research Ed.), 316*(7145), 1636-1642.

Lantz, P. M., House, J. S., Lepkowski, J. M., Williams, D. R., Mero, R. P., & Chen, J. (1998). Socioeconomic factors, health behaviors, and mortality: results from a nationally representative prospective study of US adults. *Jama, 279*(21), 1703-1708.

Lei, X., Sun, X., Strauss, J., Zhao, Y., Yang, G., Hu, P., . . . Yin, X. (2014). Health outcomes and socio-economic status among the mid-aged and elderly in china: Evidence from the CHARLS national baseline data. *The Journal of the Economics of Ageing, 3*, 29-43.

Li, S., & Xu, Z. (2008). The trend of regional income disparity in the People ' s Republic of china.

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior,,* 80-94.

Liu, M., Zhang, Q., Lu, M., Kwon, C. S., & Quan, H. (2007). Rural and urban disparity in health services utilization in china. *Medical Care, 45*(8), 767-774. doi:10.1097/MLR.0b013e3180618b9a [doi]

Luo, W., & Xie, Y. (2014). Socio-economic disparities in mortality among the elderly in China. *Population studies, 68*(3), 305-320.

Luo, Y., Zhang, Z., & Gu, D. (2015). Education and mortality among older adults in China. *Social Science & Medicine*, *127*, 134-142.

Lv, Y. B., Yin, Z. X., Chei, C. L., Qian, H. Z., Kraus, V. B., Zhang, J., ... & Zeng, Y. (2015). Low-density lipoprotein cholesterol was inversely associated with 3-year all-cause mortality among Chinese oldest old: data from the Chinese Longitudinal Healthy Longevity Survey. *Atherosclerosis*, *239*(1), 137-142.

Marmot, M. G., Stansfeld, S., Patel, C., North, F., Head, J., White, I., . . . Smith, G. D. (1991). Health inequalities among British civil servants: The Whitehall II study. *The Lancet, 337*(8754), 1387-1393.

Maskileyson, D. (2014). Healthcare system and the wealth‐health gradient: A comparative study of older populations in six countries. *Social Science & Medicine, 119*(0), 18-26. doi:http://dx.doi.org.uri.idm.oclc.org/10.1016/j.socscimed.2014.08.013

Mceniry, M. (2013). *Cross-national comparisons of health disparities among aging populations in Latin America, the Caribbean, Asia and Africa.* (No. 13-792). Ann Arbor, Michigan: Population Studies Center University of Michigan.

Mendez-Chacon, E., Santamaria-Ulloa, C., & Rosero-Bixby, L. (2008). Factors associated with hypertension prevalence, unawareness and treatment among Costa Rican elderly. *BMC Public Health, 8*, 275-2458-8-275. doi:10.1186/1471-2458-8-275 [doi]

Minkler, M., Fuller-Thomson, E., & Guralnik, J. M. (2006). Gradient of disability across the socioeconomic spectrum in the United States. *New England Journal of Medicine*, *355*(7), 695-703.

Mirowsky, J., & Ross, C. E. (1999). Economic hardship across the life course. *American Sociological Review, *, 548-569.

Mirowsky, J., & Ross, C. E. (2001). Age and the effect of economic hardship on depression. *Journal of Health and Social Behavior, *, 132-150.

Monteiro, C. A., Moura, E. C., Conde, W. L., & Popkin, B. M. (2004). Socioeconomic status and obesity in adult populations of developing countries: A review. *Bulletin of the World Health Organization, 82*(12), 940-946.

Muennig, P., Sohler, N., & Mahato, B. (2007). Socioeconomic status as an independent predictor of physiological biomarkers of cardiovascular disease: Evidence from NHANES. *Preventive Medicine, 45*(1), 35-40.

O'Rand, A. M. (1996). The precious and the precocious: Understanding cumulative disadvantage and cumulative advantage over the life course. *The Gerontologist, 36*(2), 230-238.

Pearson, T. A. (2003). Education and income: double-edged swords in the epidemiologic transition of cardiovascular disease. *Ethnicity and disease, 13*(2; SUPP/2), S2-158.

Rosero-Bixby, L., & Dow, W. H. (2009). Surprising SES gradients in mortality, health, and biomarkers in a Latin American population of adults. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 64*(1), 105-117. doi:10.1093/geronb/gbn004 [doi]

Ross, C. E., & Wu, C. (1996). Education, age, and the cumulative advantage in health. *Journal of Health and Social Behavior,* , 104-120.

Seeman, T., Epel, E., Gruenewald, T., Karlamangla, A., & McEwen, B. S. (2010). Socio‐economic differentials in peripheral biology: Cumulative allostatic load. *Annals of the New York Academy of Sciences, 1186*(1), 223-239.

Seeman, T., Merkin, S. S., Crimmins, E., Koretz, B., Charette, S., & Karlamangla, A. (2008). Education, income and ethnic differences in cumulative biological risk profiles in a national sample of US adults: NHANES III (1988‐1994). *Social Science & Medicine, 66*(1), 72-87.

Strauss, J., Lei, X., Park, A., Shen, Y., Smith, J. P., Yang, Z., & Zhao, Y. (2010). Health outcomes and socio-economic status among the elderly in china: Evidence from the CHARLS pilot. *Journal of Population Ageing, 3*(3-4), 111-142.

Taylor, S. E., & Seeman, T. E. (1999). Psychosocial resources and the SES‐health relationship. *Annals of the New York Academy of Sciences, 896*(1), 210-225.

Turra, C. M., Goldman, N., Seplaki, C. L., Glei, D. A., Lin, Y. H., & Weinstein, M. (2005). Determinants of mortality at older ages: The role of biological markers of chronic disease. *Population and Development Review, 31*(4), 675-698.

Treiman, D. J. (2012). The "difference between heaven and earth": Urban‑rural disparities in well-being in China. *Research in Social Stratification and Mobility*, *30*(1), 33-47.

United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, custom data acquired via website.

Wen, M., & Gu, D. (2011). The effects of childhood, adult, and community socioeconomic conditions on health and mortality among older adults in china. *Demography, 48*(1), 153-181.

Wilkinson, R. G., & Pickett, K. E. (2006). Income inequality and population health: A review and explanation of the evidence. *Social Science & Medicine, 62*(7), 1768-1784.

Wu, J., Liu, Y., Rao, K., Sun, Q., Qian, J., & Li, Z. (2004). Education-related gender differences in health in rural china. *American Journal of Public Health, 94*(10), 1713-1716. doi:94/10/1713 [pii]

Xu, X., Liang, J., Bennett, J. M., Botoseneanu, A., & Allore, H. G. (2015). Socioeconomic stratification and multidimensional health trajectories: evidence of convergence in later old age. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *70*(4), 661-671.

Xu, H., & Xie, Y. (2016). Socioeconomic Inequalities in Health in China: A Reassessment with Data from the 2010‑2012 China Family Panel Studies. *Social Indicators Research*, 1-21.

Yi, H., Zhang, L., Singer, K., Rozelle, S., & Atlas, S. (2009). Health insurance and catastrophic illness: A report on the new cooperative medical system in rural china. *Health Economics, 18*(S2), S119-S127.

Zeng, Y., Gu, D., & Land, K. C. (2004). A new method for correcting under-estimation of disabled life expectancy and an application to the Chinese oldest-old. *Demography, 41*(2), 335-361.

Zeng,Y., Vaupel, J. W., Zhenyu, X., Chunyuan, Z., & Yuzhi, L. (2001). The healthy longevity survey and the active life expectancy of the oldest old in china. *Population: An English Selection,* , 95-116.

Zeng, Y., Vaupel, J. W., Zhenyu, X., Chunyuan, Z., & Yuzhi, L. (2002). Sociodemographic and health profiles of the oldest old in china. *Population and Development Review, 28*(2), 251-273.

Yi, Z., Gu, D., & Land, K. C. (2007). The association of childhood socioeconomic conditions with healthy longevity at the oldest-old ages in China. *Demography, 44*(3), 497-518.

Zeng. Y., Qiushi Feng, Therese Hesketh, Kaare Christensen and James Vaupel (2016). Is increased longevity leading to compression or expansion of morbidity? -- Evidence from cohorts of the oldest-old in China. Manuscript under peer-review for consideration of publication in academic journal.Zhao, Z. (2006). Income inequality, unequal health care access, and mortality in china. *Population and Development Review, 32*(3), 461-483.

Zhu, H., & Xie, Y. (2007). Socioeconomic differentials in mortality among the oldest old in china. *Research on Aging, 29*(2), 125-143.

Zimmer, Z., Chayovan, N., Lin, H., & Natividad, J. (2004). How indicators of socioeconomic status relate to physical functioning of older adults in three Asian societies. *Research on Aging, 26*(2), 224-258.

Zimmer, Z., Wen, M., & Kaneda, T. (2010). A multi-level analysis of urban/rural and socioeconomic differences in functional health status transition among older Chinese. *Social Science & Medicine, 71*(3), 559-567.

Zimmer, Z., & Kwong, J. (2004). Socioeconomic status and health among older adults in rural and urban china. *Journal of Aging and Health, 16*(1), 44-70. doi:10.1177/0898264303260440 [doi]

Zimmer, Z., & Prachuabmoh, V. (2012). Comparing the socioeconomic status - health gradient among adults 50 and older across rural and urban areas of Thailand in 1994 and 2007. *Social Science & Medicine, 74*(12), 1921-1928. doi:http://dx.doi.org.uri.idm.oclc.org/10.1016/j.socscimed.2012.02.015

Table 1: Descriptive Statistics for SES measures and controls, by age group of respondent

Variable	Young-old N= 750	Oldest-old N= 1371
Gender		
Female	36.00%	64.00%
Marital Status		
Married	70.40%	19.30%
Non-married (widowed, divorced, never married)	29.60%	80.70%
Health insurance coverage		
Has basic health insurance	8.27%	7.15%
Socioeconomic Status		
No Education	37.90%	78.60%
Former occupation in agriculture	76.00%	85.00%

Table 2: Percent with high risk levels by age group

	Cut off point	Young-Old, 60-70 N=750 % at clinical level	Oldest-old, 80-100+ N=1371 % at clinical level	ign.
Biomarkers				
Hypertension	SBP >= 140 mmHG; DBP >=90 mm Hg; or self-report	45.5%	52.7%	*
Total cholesterol	>=6.22 mmol/L	2.5%	2.6%	.S.
HDL Cholesterol	<1.04 mmol/L	33.5%	27.9%	*
Ratio of HDL to total cholesterol	>5	9.7%	5.9%	*
Triglycerides	>=2.26 mmol/L	12.1%	7.3%	*
Glucose	>7.8 mmol/L	6.7%	6.7%	.S.
Waist Circumference (WC)	>=80 cm for women; >=90 cm for males	42.8%	30.2%	**
Body Mass Index (overweight/obese)	>=28 kg/m2	4.7%	4.0%	.S.
Body Mass Index (underweight)	<18.5 kg/m2	13.2%	37.9%	**
C-reactive protein (CRP)[a]	>3mg/L	17.0%	23.1%	*
Metabolic Syndrome	High WC and 2 of the following: diabetes, high triglycerides, low HDL cholesterol, hypertension	14.1%	8.0%	**
Count of CVD risk factors	Includ	Mean =	Mean =	

35

		1.20 (1.02)	1.06 (.90)	*
	es high WC, diabetes, hypertension, high triglycerides, high cholesterol ratio			

Self-reports of Health

Self-rated health	% good or very good	54.5%	45.6%	*
Activities of Daily Living	Needs assistance with at least 1	1.5%	20.9%	**
Instrumental Activities of Daily Living	Needs assistance with at least 1	6.9%	52.2%	**
Functional Limitations		7.6%	46.2%	**

Table 3a: Odds ratio estimates of the associations between SES and individual biomarkers being at or above clinical cut point among older adults in rural China

	High Waist Circumference	Hypertension	Total Cholesterol	High Triglycerides	CRP
Young-old	N=750	N=750	N=750	N=750	N=646
some formal education (yes=1 vs. no education=0)	0.803	1.043	0.102** *	0.246* **	0.417 ***
	[0.611, 1.056]	[0.794,1.369]	[0.0517,0.201]	[0.160,0.378]	[0.290,0.598]
Non-Agricultural	1.108	1.565	0.0744*	0.311*	0.855

36

Occupation (yes=1 vs. agriculture/fishing occupation=0)		**	**	**	
	[0.796, 1.544]	[1.12 1,2.186]	[0.0179 ,0.310]	[0.170 ,0.569]	[0.54 7,1.337]
Oldest-old	N=1371	N=1371	N=1371	N=1371	N=963
some formal education (yes=1 vs. no education=0)	0.525[*]**	1.299[*]	0.0291[*]**	0.140[*]**	0.393***
	[0.401, 0.688]	[1.01 0,1.670]	[0.0108 ,0.0787]	[0.090 3,0.217]	[0.27 6,0.560]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0)	0.549[*]**	1.138	0.0932[*]**	0.161[*]**	0.545**
	[0.395, 0.762]	[0.84 8,1.526]	[0.0374 ,0.232]	[0.086 9,0.297]	[0.35 3,0.840]

Education and former occupation are entered into separate models but presented together here.
95% confidence intervals in second row.
Models control for gender, marital status, and health insurance coverage.
***p < .001, **p < .01, *p < .05, † p<.10

Table 3b: Odds ratio estimates of the associations between SES and individual biomarkers being at or above clinical cut point among older adults in rural China

	Low HDL Cholesterol	High Cholesterol Ratio	Diabetes	Obese	Underweight
Young-old	N=750	N=750	N=750	N=750	N=750
some formal education (yes=1 vs. no education=0)	0.597***	0.262* **	0.172* **	0.190* **	0.471***
	[0.448,0.795]	[0.175,0.391]	[0.104,0.283]	[0.116,0.314]	[0.330,0.671]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0)	1.192	0.556* *	0.409* *	0.676	0.456**
	[0.846,1.678]	[0.331,0.936]	[0.213,0.784]	[0.373,1.227]	[0.271,0.767]
Oldest-old	N=1371	N=1371	N=1371	N=1371	N=1371
some formal education (yes=1 vs. no education=0)	0.672**	0.105* **	0.123* **	0.0744***	0.446***
	[0.514,0.877]	[0.061,0.179]	[0.075,0.201]	[0.040,0.138]	[0.338,0.588]
Non-Agricultural Occupation	0.683*	0.192* **	0.298* **	0.233* **	0.657**

38

(yes=1 vs. agriculture/fishing occupation=0)

	[0.49	[0.102	[0.172	[0.125	[0.48
	1,0.950]	,0.363]	,0.514]	,0.435]	2,0.894]

Education and former occupation are entered into separate models but presented together here.
95% confidence intervals in second row.
Models control for gender, marital status, and health insurance coverage.
***p < .001, **p < .01, *p < .05, † p<.10

Table 4: Odds ratio estimates of the associations between SES and composite

biomarker measures among older adults in rural China

	Meta bolic Syndrome	One CVD Risk Factor	Two CVD Risk Factors	Three CVD Risk Factors	CVD Category[a]
	N=75 0	N=75 0	N=75 0	N=750	N=75 0
Young-old some formal education (yes=1 vs. no education=0)	0.291 ***	1.624 **	0.607 ***	0.240* **	1.022
	[0.20 3,0.418]	[1.20 3,2.192]	[0.45 8,0.805]	[0.159 ,0.361]	[0.88 3,1.815]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0)					
some formal education (yes=1 vs. no education=0)	0.884	1.700 **	1.111	0.506* *	1.178 *
	[0.57	[1.15	[0.78	[0.302	[1.01

39

	9,1.351]	0,2.514]	9,1.563]	,0.848]	6,1.365]
Oldest-old	N=13 71	N=13 71	N=13 71	N=137 1	N=13 71
some formal education (yes=1 vs. no education=0)	0.194 ***	1.616 ***	0.535 ***	0.121[*] **	1.091
	[0.13 0,0.289]	[1.22 8,2.125]	[0.40 8,0.701]	[0.074 1,0.199]	[0.94 6,1.258]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0)	0.270 ***	1.25	0.573 ***	0.152[*] **	0.97
	[0.15 9,0.457]	[0.90 3,1.730]	[0.41 2,0.797]	[0.075 7,0.304]	[0.83 8,1.122]

a – Poisson regression
Education and former occupation are entered into separate models but presented together here.
95% confidence intervals in second row.
Models control for gender, marital status, and health insurance coverage.
$***p < .001, **p < .01, *p < .05, † p<.10$

Table 5: Odds ratio estimates of associations between SES and self-reported health conditions among older adults in rural China

	Good SRH	ADL Disability	IADL Disability	Function al Limitations
Young-old	N=750	N=750	N=750	N=750
some formal education	1.212	0.0699[***]	0.0701[***]	0.157[***]

40

(yes=1 vs. no education=0)	[0.923,1.593]	[0.0297,0.164]	[0.0367,0.134]	[0.0948,0.260]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0) some formal education (yes=1 vs. no education=0)	1.153 [0.826,1.610]	0.197** [0.0681,0.570]	0.285*** [0.139,0.584]	0.361** [0.186,0.702]
Oldest-old	N=1371	N=1371	N=1371	N=1371
some formal education (yes=1 vs. no education=0)	1.264 [0.985,1.621]	0.297*** [0.209,0.421]	0.618*** [0.475,0.803]	0.561*** [0.430,0.733]
Non-Agricultural Occupation (yes=1 vs. agriculture/fishing occupation=0)	1.207 [0.903,1.614]	0.645* [0.448,0.929]	0.924 [0.683,1.251]	0.722* [0.533,0.978]

Education and former occupation are entered into separate models but presented together here.

41

95% confidence intervals in second row.
Models control for gender, marital status, and health insurance coverage.
***p < .001, **p < .01, *p < .05, † p<.10

Highlights

- Examines SES and health among older Chinese living in rural longevity areas
- Examines broad array of biomarkers and self-reports of health
- Mostly positive relationships between SES and biomarkers, self-reports of health
- This research can shed light on China's health and nutrition transition