Multilevel Socioeconomic Differentials in Allostatic Load in Chinese Adults

Yue Cao

Department of Economics

University of Michigan

caoyue@umich.edu

Hongwei Xu

Survey Research Center

University of Michigan

xuhongw@umich.edu

Abstract

Socioeconomic inequalities in health have been well documented, but the underlying mechanism that relates socioeconomic status (SES) to specific health outcomes remains unclear. Capitalizing on the biomarker data from the 2009 China Health and Nutrition Survey (CHNS), we construct a health indicator, known as the allostatic load (AL), of multiple biological parameters of cardiovascular, metabolic, inflammation, and urinary systems to examine the extent to which SES gets "under the skin" to affect individuals' health among adult Chinese population. We seek to capture the effects of SES at multiple levels, ranging from individual to household, to community. Our exploratory bivariate analysis suggests a clear aging trend, a residential gap in favor of rural residents as opposed to their urban peers, and a negative education gradient in AL score.

Introduction

Socioeconomic inequalities in health have been well documented in both developed and developing countries (Alder et al. 1993; Elo, 2009; House et al., 1990). What remains unclear is the underlying mechanism that relates socioeconomic status (SES) to specific health outcomes. The growing interests and efforts in collecting biomarker data in demographic survey allow researchers to measure health status more accurately by using physiological indicators such as allostatic load (AL), compared to widely used respondents' self-reports in the literature. This in turn provides a great opportunity to better identify the biological pathway through which SES may affect health (Seeman et al. 2001).

AL is a measure of long-run health consequences resulting from multi-system physiological response to chronic stresses in order to maintain internal homeostasis. The notion of AL was introduced by McEwen and Stellar (1993), based on the concept of allostasis, which describes the ability of physiological systems to adjust to environmental challenges. McEwen and Stellar (1993) proposed that a long-term deviation from the normal range of physiological parameters as a result of allostasis can impose unnecessary strains on physiological systems and predispose individuals to disease. Such exposure and vulnerability to disease is measured by AL. To the extent that SES may reflect or trigger life time experience of stresses, AL can serve as a good intermediate mediator linking socioeconomic status (SES) and health risks.

Several studies have examined the relation between SES and AL. However, these studies often are based on the U.S. data (Merkin et al., 2009; Seeman et al., 2008), focus on aging population (Seeman et al., 2004a; Seeman et al., 2004b), or draw from a small sample (Singer & Ryff, 1999). In one study of Asian population, Seeman et al. (2004b) explored the association of social relationships and AL in Taiwanese elderly and near elderly, and found weaker patterns compared to those revealed in studies based on the U.S. population. Therefore, it is questionable whether the prevailing pattern of the association between SES and AL in western countries persists in a general adult population in a developing society such as China.

Previous research on AL often treats SES as primarily an individual characteristic, even though contextual SES beyond persons and households may have an independent impact on AL as predicted by the literature on neighborhood and health (Diez Roux, 2001; Macintyre et al., 2002). To our knowledge, so far only two cross-sectional U.S. studies (Bird et al., 2010; Merkin et al., 2009) have examined the independent effect of neighborhood SES on AL. Both studies approximated neighborhood using the 1990 U.S. Census Tract and aggregated neighborhood SES from individual SES among those living in the neighborhood. This method leaves out other important measures of neighborhood characteristics that cannot be derived from individual-level measures, such as urban development, environmental sanitation, and health-related resources, thereby subject to the risk of underestimating the neighborhood effect on AL.

Capitalizing on the recently available biomarker data from the China Health and Nutrition Survey (CHNS), this study seeks to examine the extent to which socioeconomic status gets "under the skin" to affect individuals' health in terms of biological parameters among adult Chinese population with a more comprehensive measure of neighborhood SES. More specifically, this study operationalizes the effect on AL of multilevel SES, respectively, education at individual level, household income at family level and urbanicity (Jones-Smith & Popkin, 2010) at neighborhood level. By breaking down SES into three different levels, this research is able to distinguish the independent effect of SES at each level and identify the key factors that determine individuals' AL in the context of rapidly urbanized China. The results of this research can also contribute to the understanding of the healthcare needs of Chinese population from different socioeconomic status and provide insights for policy design to improve neighborhood environment.

Data

Subjects for this study are adult participants of age 18 or older in the China Health and Nutrition Survey (CHNS), a panel survey that includes more than 4,000 households across 9 provinces in contemporary China. The CHNS data are not nationally representative, but the households were selected through a multistage, random cluster sampling process from a diverse set of nine provinces in northeast, central, and south China. All the individuals in the sampled households were interviewed. Together, these nine provinces are home to more than 40% of China's population, or 548.56 million people. The average response rate at the individual level is 88% across waves. Details on the design and sampling of CHNS are available elsewhere (Popkin et al., 2010).

Blood samples were drawn for the first time in the 2009 wave of CHNS, permitting the construction of AL from multiple biomarkers. As a multi-system composite measure, AL is constructed in a way as close to prior studies as possible. Specifically, AL is calculated from biological indicators of four major physiological systems, namely, cardiovascular, metabolic, inflammation, and urinary systems. For each system, one or more biological measures are selected, upon their availability in the CHNS, to mimic those adopted in the previous research (Seeman et al., 2010; Seeman et al., 2008). For each biological measure, a dichotomous variable is created to indicate whether the biomarker reading falls into the range of high risk (= 1) or not (= 0). The cut-points for high risk categories are chosen according to clinical guidelines. A detailed description of the biological measures considered, the reference ranges adopted, and descriptive statistics is shown in Table 1. Then final AL score is obtained by summing up all the dichotomous indicators of high risks, which is a prevailing method in the literature.

We choose different indicators to measure respondents' individual, family, and community level SES. At individual level, education is categorized into "No Schooling," "Primary School," "Junior High School," "Senior High School or Technical School," and "College or above" according to completed years of formal education. Occupation is classified into "Unemployed," "Farming," "Unskilled Worker", "Skilled Worker," and "Professional". At family level, per capita household income is divided into four quartiles within the sample to capture potential nonlinearity. We also explore alternative specifications such as logged income and its quadratic term.

At neighborhood level, we employ an urbanicity index specifically designed for the CHNS data. Capitalizing on the community data collected in the CHNS, this urbanicity index captures multiple dimensions of urbanization, including communication, economics, housing-related, and transportation infrastructure, the availability of schools, markets, and health care, environmental sanitation, and population size and density. To the extent that regional socioeconomic development is tightly linked to the urbanization process in contemporary China, the urbanicity index serves a good proxy for community level SES. Detailed information on this measure is available elsewhere (Monda et al., 2007).

In addition to the key multilevel SES indicators, we control for additional demographic variables in the analysis, including age, gender, and rural-urban residence. Age is treated as a continuous variable, while both gender and residence are dichotomous variables. We further control for provincial dummies to take into account regional heterogeneity inherent in China's large geography.

Preliminary Results

We have explored some bivariate relations between the dependent and independent variables. To begin with, Figure 1 depicts the distribution of AL scores in 2009. The skewed distribution of AL indicates that the majority of the sampled respondents were relatively healthy with no or only a few high-risk biological indicators. An aging pattern of AL is evident in that AL score increased as the respondents grew older (Figure 2). This pattern is consistent with the notion of AL as a health measure reflecting the long-term wear and tear of major regulatory systems. Gender difference is much less notable, except that the proportion of women with higher AL score (>6) was slightly greater than that of men (Figure 3). Interestingly, rural residents who are usually in a disadvantaged socioeconomic position had lower AL scores, indicating less wear and tear of body functioning, compared with their urban counterparts (Figure 4). With respect to SES measures, there does not seem to be a strong gradient of household income in AL (Figure 5). However, an evident downward trend of the average AL score is observed as the educational level increases (Figure 6).

Analytical Plan

As the next step, we plan to conduct two sets of regression analysis of the associations between AL and SES at different levels. Our first model will regress AL on the SES indicators measured contemporaneously in 2009. We will apply a three-level random effects model to take into account the hierarchical data structure of respondents nested within same households which in turn were clustered within same communities. This model will provide evidence of the cross-sectional associations. Taking advantage of the longitudinal data of the CHNS, the second model will regress AL measured in 2009 on the SES indicators measured in 2006 to gain leverage on the temporal ordering between experience of SES and health consequence. To remedy the problem of sample attrition over time, we will explore techniques such as inverse probability weighting and multiple imputation.

References

Adler, N.E., Boyce, W.T., Chesney, M.A., Folkman, S., & Syme, S.L. (1993). Socioeconomic Inequalities in Health. *Journal of the American Medical Association,* 269, 3140-3145.

Bird, C.E., Seeman, T., Escarce, J.J., Basurto-Dávila, R., Finch, B.K., Dubowitz, T., et al. (2010). Neighbourhood socioeconomic status and biological 'wear and tear' in a nationally representative sample of US adults. *J Epidemiol Community Health,* 64, 860-865.

Diez Roux, A.V. (2001). Investigating Neighborhood and Area Effects on Health. *American Journal of Public Health,* 91, 1783-1789.

Elo, I.T. (2009). Social Class Differentials in Health and Mortality: Patterns and Explanations in Comparative Perspective. *Annual Review of Sociology,* 35, 553-572.

House, J.S., Kessler, R.C., & Herzog, A.R. (1990). Age, Socioeconomic Status, and Health. *The Milbank Quarterly,* 68, 383-411.

Jones-Smith, J.C., & Popkin, B.M. (2010). Understanding community context and adult health changes in China: development of an urbanicity scale. *Social Science & Medicine,* 71, 1436-1446.

Macintyre, S., Ellaway, A., & Cummins, S. (2002). Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science & Medicine,* 55, 125-139.

McEwen, B.S., & Stellar, E. (1993). Stress and the individual: Mechanisms leading to disease. *Archives of Internal Medicine,* 153, 2093-2101.

Merkin, S.S., Basurto-Dávila, R., Karlamangla, A., Bird, C.E., Lurie, N., Escarce, J., et al. (2009). Neighborhoods and Cumulative Biological Risk Profiles by Race/Ethnicity in a National Sample of U.S. Adults: NHANES III. *Annals of Epidemiology,* 19, 194-201.

Monda, K.L., Gordon-Larsen, P., Stevens, J., & Popkin, B.M. (2007). China's transition: The effect of rapid urbanization on adult occupational physical activity. *Social Science & Medicine,* 64, 858-870.

Popkin, B.M., Du, S., Zhai, F., & Zhang, B. (2010). Cohort Profile: The China Health and Nutrition Survey - monitoring and understanding socio-economic and health change in China, 1989-2011. *International Journal of Epidemiology,* 39, 1435-1440.

Seeman, T.E., Crimmins, E., Huang, M.-H., Singer, B., Bucur, A., Gruenewald, T., et al. (2004a). Cumulative biological risk and socio-economic differences in mortality: MacArthur Studies of Successful Aging. *Social Science & Medicine,* 58, 1985-1997.

Seeman, T.E., 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, 223-239.

Seeman, T.E., Glei, D., Goldman, N., Weinstein, M., Singer, B., & Lin, Y.-H. (2004b). Social relationships and allostatic load in Taiwanese elderly and near elderly. *Social Science & Medicine,* 59, 2245-2257.

Seeman, T.E., 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, 72-87.

Seeman, T.E., Singer, B., Rowe, J., & McEwen, B. (2001). Exploring a new concept of cumulative biological risk—Allostatic load and its health consequences: MacArthur Studies of Successful Aging. *Proceedings of the National Academy of Sciences USA,* 98, 4770-4775.

Singer, B., & Ryff, C.D. (1999). Hierarchies of Life Histories and Associated Health Risks. *Annals of the New York Academy of Sciences,* 896, 96-115.

Table 1. Summary statistics of allostatic load components

Variable	Obs	Mean	Std. Dev.	High Risk Range/Reference
Cardiovascular System				
Systolic blood pressure	9366	122.738	19.872	>=140 mmHg [a]
Diastolic blood pressure	9366	79.359	11.873	>=90 mmHg [a]
Metabolic System				
Waist-to-hip ratio	9203	0.870	0.079	Male: >0.9; Female: >0.85 [b]
Body Mass Index	9326	22.873	3.831	>=25 [b]
High-density lipoprotein (HDL) cholesterol	9499	55.601	19.288	Male: <40 mg/dl; Female: <50 mg/dl (American Heart Association)
Low-density lipoprotein (LDL) cholesterol	9497	112.653	38.580	>130 mg/dl [a]
Total cholesterol	9500	184.846	39.526	>=200 mg/dl [a]
Triglycerides	9500	143.433	128.523	>=160 mg/dl
HbA1c	9454	5.599	0.895	>=7% [c]
Fasting glucose	9492	95.697	25.368	>=126 mg/dl [d]
Inflammation System				
High-sensitivity C-reactive protein(CRP)	9499	0.250	0.876	>=0.3 mg/dl [a]
Albumin	9500	4.755	0.348	<3.8 g/dl
Urinary System				
Creatinine clearance	9498	0.973	0.259	18-19 y: 0.50-1.00 mg/dl; Male: 20 y-: 0.66-1.25 mg/dl; Female: 20 y-: 0.52-1.04 mg/dl [e]
Uric acid	9498	5.182	1.755	Male: 18 y-: 3.5-8.5mg/dl; Female: 18-34 y: 2.5-6.2 mg/dl; 35-44 y: 2.5-7.0 mg/dl; 45 y-: 2.5-7.5mg/dl [e]

a. American Heart Association
b. World Health Organization
c. American Diabetes Association
d. International Diabetes Federation
e. Minnesota Reference provided by CHNS

Figure 1. The distribution of allostatic load

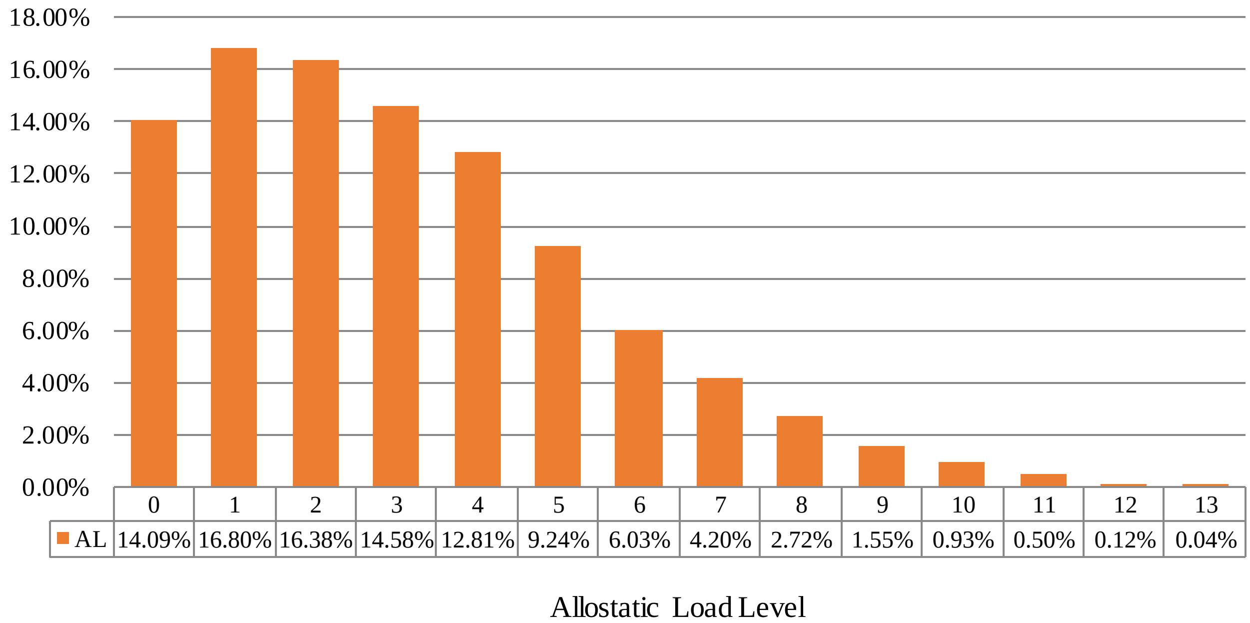


Figure 2. Average allostatic load score by age groups

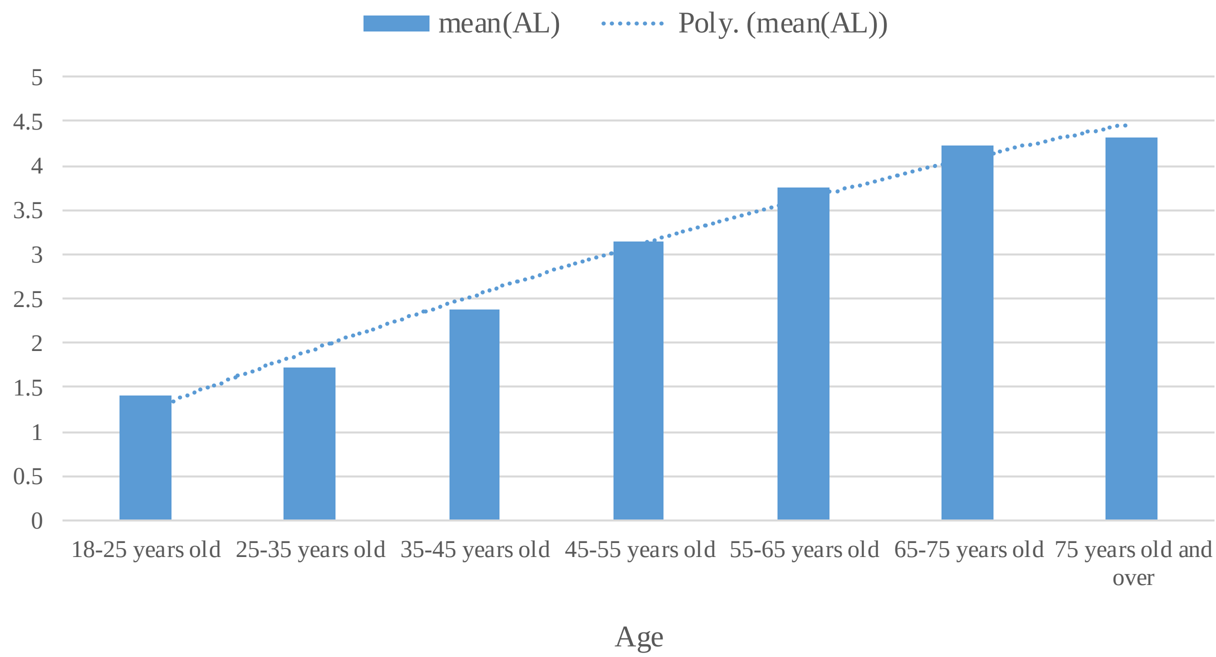
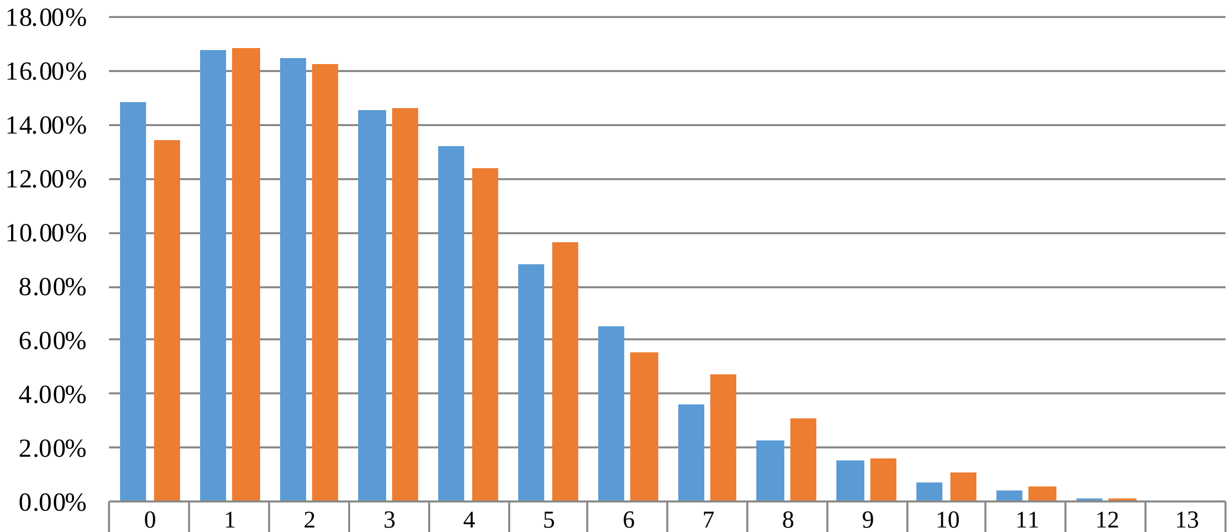


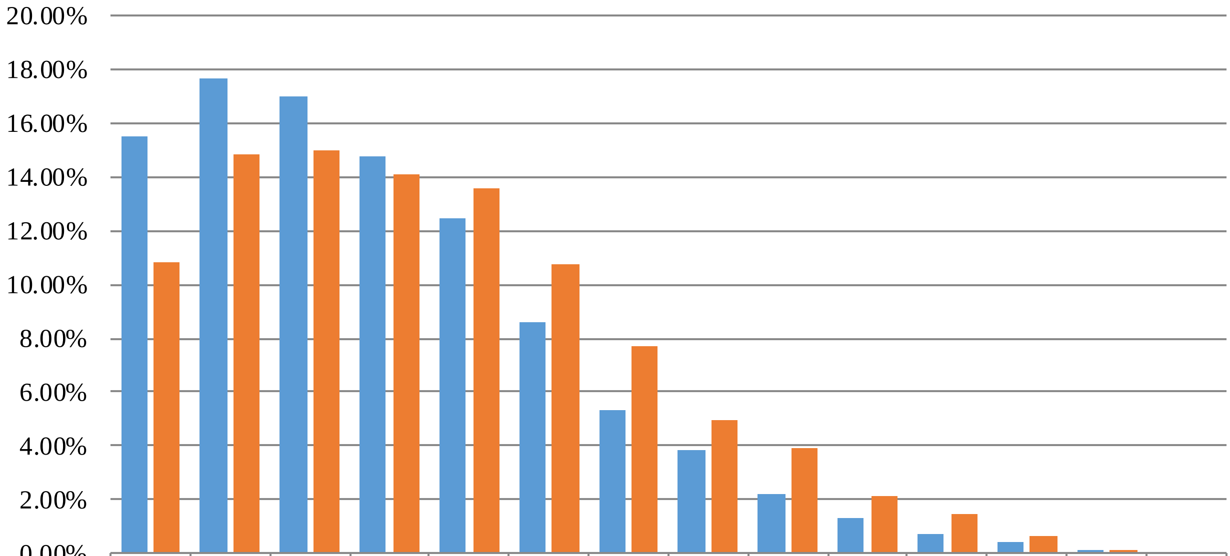
Figure 3. Distribution of allostatic load by gender



	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Male	14.88%	16.78%	16.47%	14.54%	13.23%	8.80%	6.55%	3.60%	2.30%	1.51%	0.73%	0.42%	0.16%	0.03%
Female	13.42%	16.83%	16.28%	14.62%	12.42%	9.63%	5.59%	4.72%	3.09%	1.59%	1.11%	0.57%	0.09%	0.05%

Allostatic load level

Figure 4. Distribution of allostatic load by rural-urban residence



	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Rural	15.53%	17.66%	17.00%	14.80%	12.46%	8.57%	5.31%	3.87%	2.20%	1.31%	0.72%	0.42%	0.12%	0.03%
Urban	10.81%	14.84%	14.96%	14.08%	13.60%	10.77%	7.70%	4.95%	3.91%	2.11%	1.44%	0.68%	0.12%	0.04%

Allostatic load level

Figure5. Average allostatic load score by quartiles of per capita household income

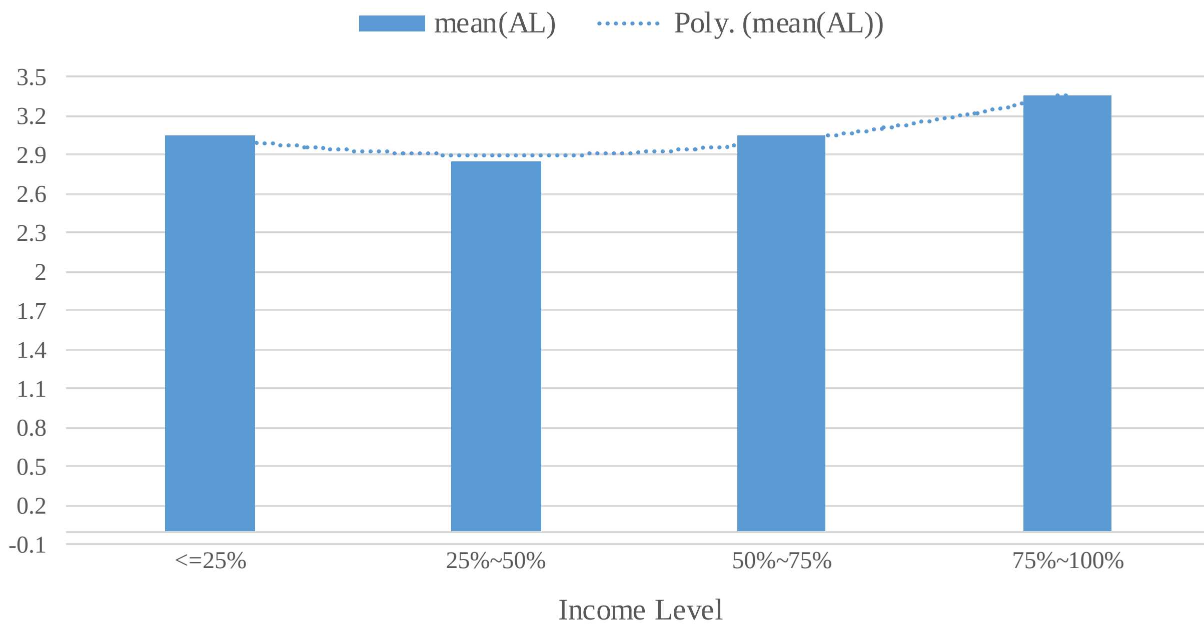


Figure 6. Average allostatic load by education