Title: Gender differences in the association of cardiovascular risk factors with education: a comparison of Costa Rica (CRELES) and the United States (NHANES)

David H. Rehkopf, University of California, San Francisco, USA

William H Dow, University of California, Berkeley, USA

Luis Rosero-Bixby, Universidad de Costa Rica, San Jose, Costa Rica

Draft paper: prepared for the XXVI IUSSP International Population Conference

Draft date: 14 September 2008

Abstract

Despite different levels of economic development, Costa Rica and the United States have surprisingly similar mortality rates among women and men. In contrast to the United States, in Costa Rica there are only minor differences in adult mortality rates by education. We used data on adults aged 60 and over from the Costa Rican Healthy Aging Study (CRELES) and from the United States National Health and Nutrition Examination Survey NHANES to analyze the cross sectional association between educational level and risk factors for coronary heart disease (CHD) among men and women. Among the 17 gender specific outcomes examined, the only association with education that was similar across the two countries was for sedentary behavior among women. We find that there is not a uniform association of education with risk factors in the U.S. nor a uniform lack of association with education in Costa Rica.

background

While in developed western countries [1, 2] and some non-western countries[3] there is a generally observed association of lower educational attainment with greater risk of mortality, others have described the historically contingent and contextually specific nature of such associations [4]. A recently documented example of a different mortality pattern with respect to educational attainment is among the elderly of Costa Rica. Examinations of education associations in a population of Costa Ricans age 60 and above shows relatively minor associations with education [5], despite the fact that the usual maternal education gradients are apparent among children. While education differentials in mortality are generally smaller at older ages [6-9], recent analysis of individuals in the U.S. of a similar age reveal substantively significant differentials in mortality by education, with rates 5-6% higher per year for each year less of education [10]. This contrast between adult mortality gradients by education in the United States versus Costa Rica thus motivates a more detailed examination for other health dimensions. The patterns revealed in the current analysis will help in future assessments of the plausibility of various hypothesized pathways for achieving social equity in adult health.

Costa Rica is a case of particular interest because of its historic emphasis on progressive social and health sector programs. The country began investing in female education in the late 19th century, abolished the army in the mid 20th century, invested heavily in public health initiatives such as clean water, has strongly promoted primary care initiatives in its medical sector, and adopted national health insurance in the 1970s. Costa Rica's high overall life expectancy (higher even than the United States) has been linked to its social investments [11], but until the recent CRELES survey little data has been available to understand why there is a lack of social class differences in adult mortality in Costa Rica. This paper explores in detail the lack or presence of education gradients in risk factors for CHD mortality in Costa Rica in comparison with differences in the United States in order to understand the biologic and behavioral pathways that combine to create the education differences (US) or similarities (Costa Rica) in mortality.

There have been several hypotheses for explaining the aggregated general associations of adult mortality and education. One of these is the theory of social conditions as fundamental causes of disease. This theory posits that socioeconomic resources, for example as measured by educational attainment, effect multiple risk factors for diseases. This is posited to occur through the ability of people to use resources to avoid multiple causes of risk – and implies some similarity of the association of education with multiple causal pathways to a particular disease outcome. Other theories involve the primacy of factors including technical progress in medical care [12, 13], the importance of time preferences [14, 15], social rank [16] or income inequality [17]. Within each of these proposed drivers of heterogeneity in mortality, proponents generally do not focus on particular pathways, but imply more general effects on disease processes. An alternative explanation of the mortality education association is that a more complex pattern of the association of education and biological pathways exists – with education associations with risk factors that are not uniform but rather only on balance create the educational differences observed for mortality. Whether data are more consistent with either of these potential explanations has important implications for policies to decrease the link between lower levels of education and higher rates of mortality.

In order to explore the differing education-mortality links in elderly populations from Costa Rica and the United States, and shed light on the consistency of biological pathways to disease with major theories of factors driving educational differences in adult mortality, we investigate whether data are more consistent with either more or less uniform educational associations with risk factors and biological mechanisms of disease. We focus on this with respect to coronary heart disease (CHD), both because a substantial part of the education disparities in mortality in the United States are from CHD [18] and roughly 40% of deaths at ages 60 and over in Costa Rica are due to cardiovascular diseases [19], but also because the individual risk factors and biological pathways underlying this broad cause of mortality are relatively well understood.

Critical to valid international comparisons are the appropriate comparability of both predictor (i.e. education) and outcomes (i.e. CHD risk factors). As a factor that has relevance within a particular context, the most appropriate comparison of education is not a literal one year of education in Costa Rica is equivalent to one year of education in the United States, but rather a comparison of levels with an equivalent social and economic meaning. With respect to outcomes, prior work indicates that there are not substantial variations between countries in the risk factors predicting CHD [20].

Our approach to understanding the different associations of education and mortality in Costa Rica and the United States is to examine the relative strength of education gradients in risk factors for CHD, both biological and behavioral. Our choice of risk factors was guided by the published guidelines of the American Heart Association [21], the American College of Cardiology [22, 23], and the World Health Organization [24]. With respect to education level we examine the associations with 8 continuous biological risk factors for CHD (HDL cholesterol, LDL cholesterol, triglycerides, glycosylated hemoglobin, fasting glucose, C-reactive protein, systolic blood pressure and BMI) and 9 dichotomous behavioral and anthropometric risk factors (lifetime smoking, current smoking, sedentary, high saturated fat diet, high carbohydrate diet, high calorie diet, obesity, severe obesity, waist circumference), factors which together explain the majority of CHD risk [21, 25]. While some of these risk factors are related and we examine the impact of similar behavioral factors, we include each of these risk factors separately because of potentially different associations with education in each country. A clinical understanding of the etiology of the development of cardiovascular disease emphasizes the importance of exposures over the life course for producing levels of biological risk markers [26-29], in addition to current behaviors [30]. Thus while our analysis of behavioral risk factors focuses on current assessment of exposures, the biomarkers and anthropometric measures should be interpreted as the cumulative result of exposures across the life course [31].

Methods

Samples

Data from Costa Rica is from the Costa Rican Study on Longevity and Healthy Aging (CRELES), a longitudinal, nationally representative, probabilistic sample of adults aged 60 and over selected from the 2000 census database. A selected sub-sample of this population (n=1329 men, n=1498 women) with over-sampling of the oldest old completed an in depth survey in their household which is the basis of the analytic sample for our analyses. This sub-sample was drawn from a larger number of individuals selected from the 2000 census with the following non-response rates: 19% of individuals were deceased by the contact date, 18% could not be found, 2% had moved and 4% rejected the interview. Among those interviewed, 95% provided a fasting blood sample. Data from the United States is from the National Health and Nutrition Examination Survey 1999-2004, restricted to adults aged 60 and over (n=2411 men, n=3196 women). This cross-sectional data is representative of the non-institutionalized population of the United States. In both NHANES and CRELES prevalence of hypertension, hypercholesterolemia and diabetes were assessed by clinical cut-offs (Systolic > 140 mm Hg or diastolic > 90 mm Hg, total cholesterol: HDL ratio of >= 5.92 and HbA1c > 6.5%, respectively).

Demographic, health related behaviors and dietary measures

Our primary exposure of interest is attained level of formal education. Since educational attainment in Costa Rica is substantially lower, and levels of education of different social and economic meaning differ in each context, it does not make sense to use the same categories in each country. For Costa Rica, educational attainment was categorized into three groups: less than 3 years of education, from three to six years of education (elementary school comprises six grades), and at least one year of high school. For the United States, we use the educational categories of less than high school, high school or greater than high school. We performed extensive sensitivity analyses to our choice of age categories and results were generally robust to alternative education specifications in Costa Rica (data not shown, available upon request).

We present data on three health related behaviors, current smoking, lifetime smoking and physical activity. In both NHANES and CRELES never smoked was assessed by the question “Have you smoked more than 100 cigarettes or cigars in your life?” and current smoking was assessed by the question “Do you smoke now?” In CRELES, sedentary behavior was defined as participants responding “no” to the question “In the last 12 months, did you exercise regularly or do other physical rigorous activities like sports, jogging, dancing, or heavy work, three times a week?” In NHANES, sedentary behavior was assessed by whether individuals reported physical activity less than 13 times in the last 30 days, and answered “No” to the question of “you do heavy work or carry heavy loads” as an average level of physical activity each day.

CRELES collected dietary data using a modified version of a food-frequency questionnaire (FFQ) that was developed and validated specifically to assess nutrient intake among the Costa Rican adult population in an earlier study [32, 33]. Dietary averages in NHANES were based on calculations from two 24 hour dietary recalls [34]. These survey data were used to calculate grams of saturated fat, grams of carbohydrates and number of calories consumed per day. Standard cut points associated with differential risk of cardiovascular disease were used to create dichotomous variables as follows: high saturated fat diet (> 40 grams per day), high carbohydrate diet (> 200 grams per day) and high calorie diet (> 3000 kcal/day).

Anthropometric and biomarker outcomes

We present associations with four anthropometric and seven biomarker outcomes that are the most well established biological risk factors for coronary heart disease. For anthropometric measures we examine BMI (as continuous), obese (BMI > 30), severely obese (BMI > 40) and large waist (> 102 cm among men, > 88 cm among women) all based on standard clinical cut-points. In both studies height and weight were measured and waist circumference was measured at the midaxillary line

The seven biomarkers examined were high density lipoprotein cholesterol (HDL cholesterol), low density lipoprotein cholesterol (LDL cholesterol), triglycerides, glycosylated hemoglobin (HbA1c), fasting glucose, systolic blood pressure and C-reactive protein (CRP). All biomarkers were measured using similar methods in both countries. If multiple blood pressure readings were taken the first reading was excluded from the average [35].

Statistical analysis

All analyses accounted for over-sampling and clustered sampling in both NHANES and CRELES using the survey package in STATA 9 using sampling weights and clustering at the PSU level (n=49) in NHANES and at the health area level in CRELES (n=60 health areas). Continuous outcomes were analyzed using linear regression and dichotomous outcomes were analyzed using logistic regression, both controlling for age and age squared. Because there were statistically significant interactions between education and gender for a number of outcomes in both countries (data not shown, available upon request), all analyses are presented stratified by gender. In NHANES, analyses of blood glucose, LDL cholesterol and triglycerides were examined only in the randomly assigned fasting sub-sample (n=1016 men, n=1065 women).

results

Table 1 shows the distribution of demographic characteristics, health behaviors, dietary averages, anthropometric measures and prevalent health conditions in CRELES and NHANES by gender. While the age distributions are similar, the population of the United States is somewhat older. Among health behaviors related to cardiovascular disease mortality, Costa Rica has a slightly higher percentage of current smokers among men (17% vs 14%), but a lower percent among women. The proportion of ever smokers is similar among men, but the United States has a much higher percentage of women who had ever smoked. Comparing anthropometric measures, men and women in the United States were more likely to be obese, severely obese and have a larger waist circumference, with higher proportions of each among women than among men in both countries. In the U.S. there were lower levels of hypertension, higher levels of hypercholesterolemia, and lower levels of diabetes (among women), as measured by self-report of physician diagnosis, treatment of condition or biomarkers.

Figure 1 shows a comparison (NHANES – solid lines, CRELES – dashed lines) of the population distribution of seven biological risk markers for CHD (HDL cholesterol, LDL cholesterol, triglycerides, hemoglobin A1c, fasting glucose, systolic blood pressure and C-reactive protein),as well as for BMI. Median values are shown by vertical lines. All median differences shown are statistically significantly different at the alpha = 0.05 level except for LDL. Costa Ricans show substantially higher of triglycerides and systolic blood pressure and substantially lower BMI. The overall distribution of these biological risk factors are generally similar between NHANES and CRELES, with the exception of upwardly shifted distributions of systolic blood pressure in CRELES, and a higher right hand tail of BMI distribution in the United States (appendix table A1 shows the means and standard errors for these biological risk markers among men and women).

Figure 2 shows differences in smoking, physical activity, diet and anthropometric measures by educational attainment, controlling for age, age-squared and stratified by gender (appendix table A2 shows the odds ratios and confidence intervals). The figure shows the controlled odds ratios for the educational categories two and three, using the lowest education category as reference. The width of the bar is proportional to the size of the group. The odds ratios (OR) can be interpreted as prevalence of the outcome in either education category two or three as compared to the lowest education category. In Costa Rica, there was a higher proportion of individuals with a high saturated fat diet among the most educated. Among Costa Rican men, the most educated were more likely to be obese and more likely to have a large waist circumference. Among women, there was a lower probability of lifetime smoking and being sedentary among more educated women and a higher probability of having a high calorie diet. In the United States, more educated individuals were significantly less likely to be sedentary. Among men in the U.S., more educated were less likely to be current smokers, less likely to be lifetime smokers, but more likely to have a high carbohydrate and a high calorie diet. Among women, more educated women were less likely to be obese and have a large waist circumference. Thus for 2 out of 9 outcomes in Costa Rica and 5 out of 9 outcomes in the United States, individuals with higher levels of education had less hazardous levels of the risk factors.

For 4 out of 9 risk factors in Costa Rica and 2 out of 9 risk factors in the United States individuals with higher levels of education had more hazardous levels of risk factors.

Figure 3 shows differences in levels of eight biological risk factors for CHD by educational attainment, controlling for age, age-squared and stratified by gender (appendix table A3 shows the odds ratios and confidence intervals). The plotted betas for categories education categories two and three from these linear regression models can be interpreted as absolute differences in the level of the biomarker as compared to the lowest education category. In Costa Rica, higher educational attainment is associated with lower levels of LDL among men, and associated with lower levels of HbA1c and systolic blood pressure in women. Among men in the United States, there are higher levels of triglycerides among men in the middle education category. Among women in the United States, among the more educated there were higher (lower risk) levels of HDL cholesterol, lower levels of fasting glucose, lower levels of C-reactive protein, and lower levels of BMI.

Thus overall there were significantly less hazardous levels of risk biomarkers at higher levels of education for more than half of the (9 out of 17) of the risk factor outcomes in the United States. This was true for less than a third of the gender specific outcomes in Costa Rica (5 out of 17). In Costa Rica higher levels of education were associated with higher risk levels for approximately one quarter (4 out of 17) of the risk factor outcomes, while this was the case for 3 out of 17 risk factors in the United States.

Discussion

We found that there was not a uniform lack of education differentials of risk factors in Costa Rica nor a universal presence of education differentials in risk factors in the United States. Rather we found education differentials in the U.S. driven by lower levels of current smoking, lifetime smoking and sedentary among more educated men and lower levels of sedentary, obesity, large waist circumference, fasting glucose, C-reactive protein, BMI and higher HDL cholesterol among more educated women. In Costa Rica, there are a number of important risk factors (e.g. smoking, higher systolic blood pressure and sedentary) that are more prevalent among the less educated, but these are not uniform enough or balance with other risk factors such as obesity (among men), or overall high calorie and saturated fat diets to result in the observed lack of association of education with mortality. Highlighting the differential importance of education depending on country context, among the 17 gender stratified outcomes examined, the only similarly statistically significant education differentials we observed were for sedentary behavior among women. These observations are not consistent with universal effects associated with educational attainment underlying the most clearly documented risk factors for CHD. At least in these two countries, there is little evidence for ubiquitous associations between education and risk factors for CHD.

Before describing the implications of our results, there are a few limitations to this descriptive study. The first is that multiple risk factors may act together [22], and the clustering of risk factors may be different in each country, and this may be critical for understanding educational differentials in mortality. Future work should investigate the importance of multiple risk factor interactions for educational differences in CHD. A second limitation is that there may be other biological pathways with different education associations that we don't examine, giving an incomplete picture of the consistency of pathways. While work continues to identify novel risk factors for CHD, it is generally considered to be unlikely that there are substantial independent biological pathways to CHD that are undiscovered. Novel risk factors not included in our analysis have not emerged as independent predictors of CHD to an extent that they are currently considered in the major CHD risk prediction equations recommended for use by clinicians.[22, 31] Analysis of the extent to which cardiovascular mortality can be explained by known risk factors also reveals that associations with SES became non-significant after controlling for a limited number of known risk factors [36]. A third potential limitation is the extent to which racial/ethnic minorities in the U.S. are the reason for the differences in the association of education with risk factors between countries. While we include the full population of the U.S. in the results we present, we also re-analyzed our data using only the white population of the United States, and results did not change substantively (data not shown, available from authors upon request). A fourth limitation is the difficulty in choosing appropriate educational comparison groups. Again, our approach here was to do a sensitivity analysis with alternative educational categories in Costa Rica, which did not meaningfully change our findings. Finally, perhaps the most important limitation to our understanding of the causes of these biological differences and behavioral differences by education is that our data represents a cross-sectional assessment of individuals, and past behaviors and exposures are unknown. Somewhat mitigating this limitation, however, is that our primary interest in this analysis is in documenting the biological mechanisms by which educational differences in health occur, and the biomarkers we present, while values are based on current behaviors, also are reflective of lifelong exposures and behaviors.

Prior work has also sought to understand international differences in risk factors underlying CHD mortality[2, 37]. In a comparison of education differences of five CHD risk factors in a younger population (age 40-70) in the United States and England, the authors focused on differences in risk factor levels between these countries, rather than testing differences in risk markers by education within countries[37]. However, examining this data qualitatively reveals similar education differences between the United States and England for dichotomized measures of HbA1c, blood pressure, C-reactive protein, fibrinogen and HDL cholesterol. There were also similar educational differences in current smoking, ever smoking and obesity. These results contrast dramatically with the differences by educational level that we have shown between the United States and Costa Rica. In a study of educational differences in the percent of current smokers and percent of individuals overweight across 11 European Union countries, substantial variation was found for educational differences in overweight among men (odds ratios ranging from 0.87 to 2.00 for low education vs. all other categories) and current smoking among women (odds ratios ranging from 0.32 to 1.94 for low education vs. all other categories).[38]

Our original motivating question was to determine whether risk factor and education associations were absent in Costa Rica and present and consistent across examined factors in the United States, or whether there was a balance of different types of risk factor associations with education which lead to the observed mortality-education associations. Our findings are consistent with the latter. This is also less supportive of any one factor having a majority influence on educational differences in mortality. Nevertheless, a number of overarching theories may still be relevant, but based on our findings, their effects may be more specific to particular pathways. While this complexity may in some senses be daunting for efforts to reduce income disparities in mortality, a lack of universal associations with education also implies potentially more tractable approaches of focusing on the particular risk factors that are most responsible for the differences in disparities. In the United States, this takes the form of approaches to reduce education disparities, and in Costa Rica, efforts to prevent their emergence.

Future investigations can build on this comparative descriptive work in pursuing more causal analyses of the differences in educational impacts on health within the different contexts of the United States and Costa Rica, in particular focusing on the factors we identified as most associated with education. The understanding of social gradients in health more broadly can greatly benefit from international comparisons as a method of understanding country level influences. However, to make any attribution to country specific factors, a larger sample of countries is likely to be necessary. In addition, future work will benefit from examining the longer term changes in education gradients within each of these countries.

Acknowledgments

The CRELES project (Costa Rica: study of longevity and healthy aging) is a longitudinal study of the *Universidad de Costa Rica*, carried on by the *Centro Centroamericano de Población* in collaboration with the *Instituto de Investigaciones en Salud*, with the support of the Wellcome Trust Foundation (grant N. 072406). Principal Investigator: Luis Rosero-Bixby. Co-principal investigators: Xinia Fernández and William H. Dow. Collaborating investigators: Ericka Méndez, Guido Pinto, Hannia Campos, Kenia Barrantes, Floribeth Fallas, Gilbert Brenes, and Fernando Morales. Informatics and support staff: Daniel Antich, Aaron Ramírez, Jeisson Hidalgo, Juanita Araya, and Yamileth Hernández. Field workers: José Solano, Julio Palma, Jenny Méndez, Maritza Aráuz, Mabelyn Gómez, Marcela Rodríguez, Geovanni Salas, Jorge Vindas and Roberto Patiño.

references

[1] Backlund E, Sorlie PD, Johnson NJ. A comparison of the relationships of education and income with mortality: the national longitudinal mortality study. Social Science and Medicine. 1999;49:1373-84.

[2] Mackenbach JP, Kunst AE, Cavelaars AE, Groenhof F, Geurts JJ. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. Lancet. 1997 Jun 7;349(9066):1655-9.

[3] Son M, Armstrong B, Choi JM, Yoon TY. Relation of occupational class and education with mortality in Korea. J Epidemiol Community Health. 2002 Oct;56(10):798-9.

[4] Kunitz S. Sex, race and social role - history and the social determinants of health. Int J Epidemiol. 2007;36:3-10.

[5] Rosero-Bixby L, Dow WH, Lacle A. Insurance and other socioeconomic determinants of elderly longevity in a Costa Rican panel. J Biosoc Sci. 2005 Nov;37(6):705-20.

[6] Elo IT, Preston SH. Educational differentials in mortality: United States, 1979-85. Soc Sci Med. 1996 Jan;42(1):47-57.

[7] Crimmins, E. M. (2005). Socioeconomic differentials in mortality and health at the older ages. Genus, LXI(1), 163-178.

[8] Elo, I. T., & Preston, S. H. (1996). Educational differentials in mortality: United States, 1979-85. Social Science & Medicine, 42(1), 47-57.

[9] Turra, C. M., & Goldman, N. (2007). Socioeconomic Differences in Mortality Among U.S. Adults: Insights Into the Hispanic Paradox. Journal of Gerontology: Social Sciences, 62(3), S184-S192.

[10] Steenland K, Henley J, Thun M. All-cause and cause-specific death rates by educational status for two million people in two American Cancer Society cohorts, 1959-1996. Am J Epidemiol. 2002 Jul 1;156(1):11-21.

[11] Rosero-Bixby L. Evaluacion del impacto de la reforma del sector salud en Costa Rica. Revista Panamericana de salud Publica. 2004;15:94-103.

[12] Cutler DM, Deaton A, Lleras-Muney A. The Determinants of Mortality. NBER Working Paper. 2006;11963.

[13] Cutler DM, McClellan M. Is technological change in medicine worth it? Health affairs (Project Hope). 2001 Sep-Oct;20(5):11-29.

[14] Fuchs VR. Time preference and health: an exploratory study. NBER Working Paper. 1982;539.

[15] Fuchs VR. Reflections on the socio-economic correlates of health. Journal of Health Economics. 2004;23:653-61.

[16] Marmot M. The Status Syndrome: How Social Standing Affects Our Health and Longevity. New York: Henry Holt and Company 2004.

[17] Wilkinson RG. The Impact of Inequality: How to Make Sick Societies Healthier. New York: The New Press 2005.

[18] Wong MD, Shapiro MF, Boscardin J, Ettner SL. Contributions of Major Diseases to Disparities in Mortality. New England Journal of Medicine. 2002;347:1585-92.

[19] Ministerio de Salud. La salud de las personas adultas mayores de Costa Rica. San Jose, Costa Rica: OPS; 2004.

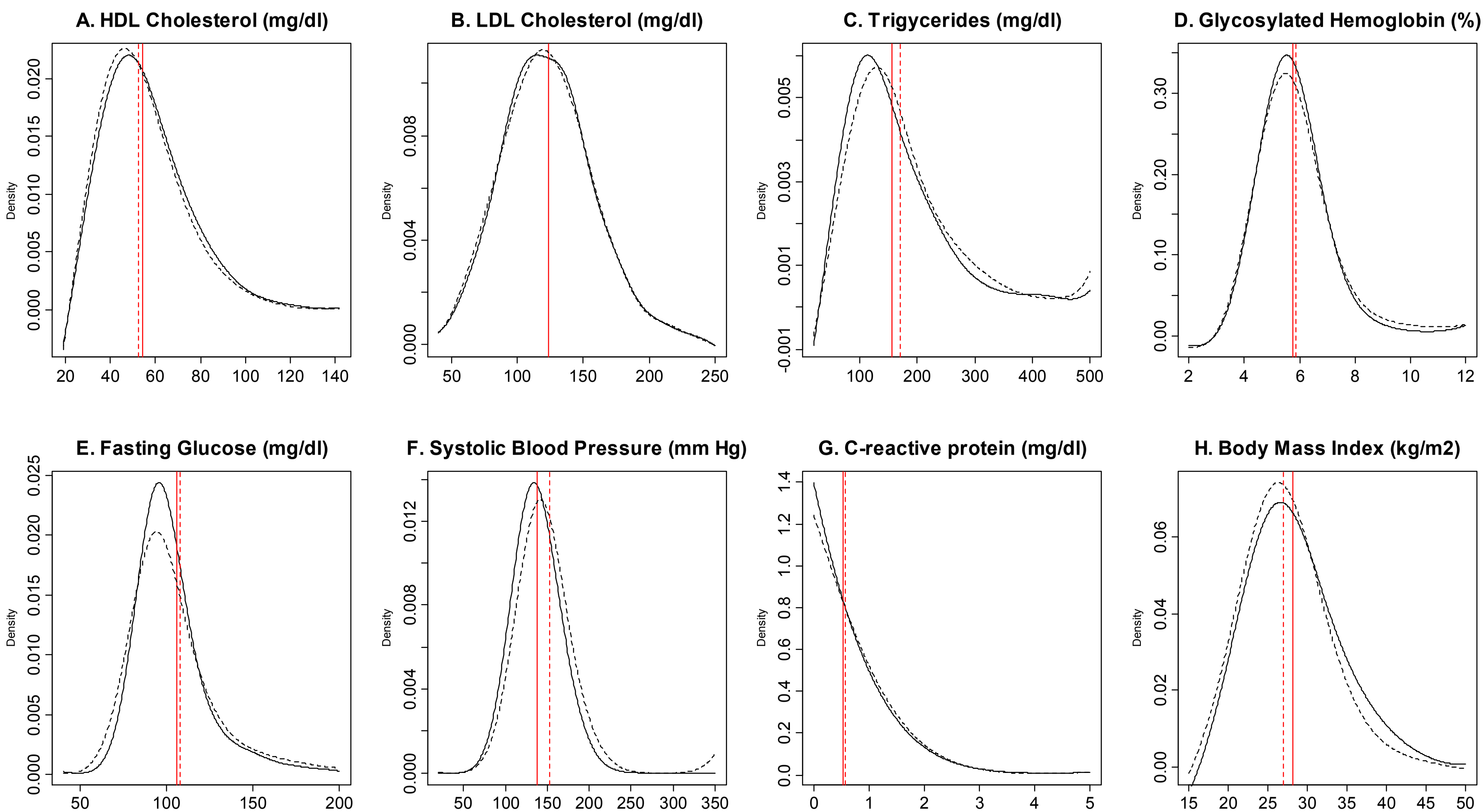
[20] Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):937-52.
[21] American Heart Association Statement. AHA dietary guidelines: revision 2000: a statement for healthcare professionals from the Nutrition Committee of the American Heart Association. Circulation. 2000;102:2284-99.
[22] Grundy SM, Pasternak R, Greenland P, Smith S, Jr., Fuster V. AHA/ACC scientific statement: Assessment of cardiovascular risk by use of multiple-risk-factor assessment equations: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology. J Am Coll Cardiol. 1999 Oct;34(4):1348-59.
[23] Grundy SM, Pasternak R, Greenland P, Smith S, Jr., Fuster V. Assessment of cardiovascular risk by use of multiple-risk-factor assessment equations: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology. Circulation. 1999 Sep 28;100(13):1481-92.
[24] Mackay J, Mensah G. Atlas of Heart Disease and Stroke. Geneva; 2004.
[25] Expert Panel on Detection Evaluation and Treatment of High Blood Cholesterol in Adults (Adults Treatment Panel III). Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP). Jama. 2001;285:2486-97.
[26] Davey Smith G, Hart C, Blane D, Hole D. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. BMJ. 1998;316:1631-5.
[27] Lawlor DA, Davey Smith G. Early life determinants of adult blood pressure. Current Opinion in Nephrology and Hypertension. 2005;14:259-64.
[28] Lawlor DA, Taylor M, Davey Smith G, Gunnell D, Ebrahim S. Associations of components of adult height with coronary heart disease in postmenopausal women: the British women's heart and health study. Heart. 2004;90:745-9.
[29] Lynch J, Davey Smith G. A Life Course Approach to Chronic Disease Epidemiology. Annu Rev Public Health. 2005;26(26):1-35.
[30] Brunner E, Shipley MJ, Blane D, Smith GD, Marmot MG. When does cardiovascular risk start? Past and present socioeconomic circumstances and risk factors in adulthood. J Epidemiol Community Health. 1999 Dec;53(12):757-64.
[31] Kromhout D, Menotti A, Kesteloot H, Sans S. Prevention of Coronary Heart Disease by Diet and Lifestyle: Evidence From Prospective Cross-Cultural, Cohort, and Intervention Studies. Circulation. 2002;105:893-8.
[32] Kabagambe EK, Baylin A, Allan DA, Siles X, Spiegelman D, Campos H. Application of the method of triads to evaluate the performance of food frequency questionnaires and biomarkers as indicators of long-term dietary intake. Am J Epidemiol. 2001;154(12):1126-35.
[33] El-Sohemy A, Baylin A, Ascherio A, Kabagambe E, Spiegelman D, Campos H. Population-based study of alpha- and gamma-tocopherol in plasma and adipose tissue as biomarkers of intake in Costa Rican adults. Am J Clin Nutr. 2001;74(3):356-63.
[34] NCHS. The NHANES 1999-2001 Dietary Interviews Procedure Manual. Hyattsville; 2000.
[35] NCHS. NHANES III Examination Data File Documentation: National Center for Health Statistics; 1996 December 1996. Report No.: Catalog Number 76200.

[36] Lynch J, Kaplan G, Cohen RD, Tuomilehto J, Salonen JT. Do Cardiovascular Risk Factors Explain the Relation between Socioeconomic Status, Risk of All-Cause Mortality, Cardiovascular Mortality, and Acute Myocardial Infarction? American Journal of Epidemiology. 1996;144:934-42.
[37] Banks J, Marmot M, Oldfield Z, Smith JP. Disease and Disadvantage in the United States and in England. Jama. 2006;295:2037-45.
[38] Cavelaars AE, Kunst AE, Mackenbach JP. Socio-economic Differences in Risk Factors for Morbidity and Mortality in the European Community. Journal of Health Psychology. 1997;2:353-72.

Table 1: Demographic and health related characteristics of Costa Rica (CRELES) and the United States (NHANES) (column proportion)

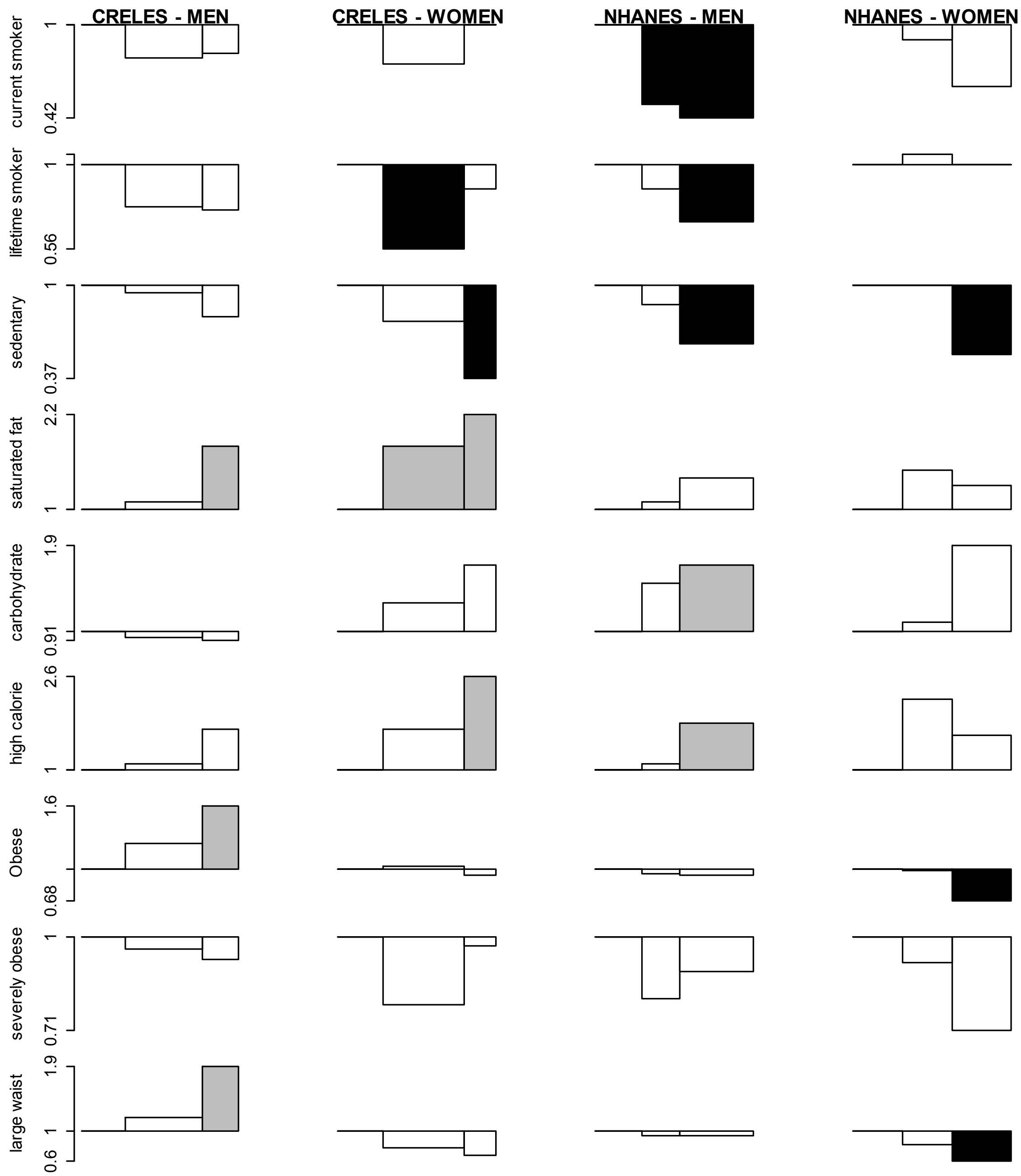
	Costa Rica		United States	
	n=1329	n=1498	n=2411	n=3196
	men	women	men	Women
Demographic				
Age				
60-64	0.31	0.29	0.26	0.24
65-74	0.42	0.41	0.44	0.40
75-84	0.21	0.22	0.24	0.29
>85	0.06	0.07	0.06	0.08
education (Costa Rica/United States)				
<3 years elementary / <high school	0.28	0.28	0.29	0.31
> 3 years elementary / high school	0.49	0.52	0.24	0.32
at least 1 year high school / >high school	0.23	0.20	0.46	0.36
married or partner	0.77	0.47	0.77	0.46
health behaviors				
current smoker	0.17	0.04	0.14	0.10
ever smoked	0.68	0.21	0.69	0.41
not physically active	0.60	0.77	0.63	0.71
Diet				
high saturated fat diet (>40 g/day)	0.16	0.12	0.13	0.04
high carbohydrate diet (>400 g/day)	0.20	0.11	0.07	0.02
high calorie diet (>3000 kcal/day)	0.16	0.09	0.09	0.02
Anthropometric				
obese (BMI>=30)	0.23	0.36	0.36	0.40
severely obese (BMI >=40)	0.07	0.11	0.10	0.14
waist (>102 cm men, > 88 cm women)	0.25	0.67	0.59	0.75
prevalent health conditions				
hypertension (sys/diastolic > 140/90)	0.55	0.60	0.35	0.50
hypercholesterolemia (TC:HDL>5.92)	0.33	0.26	0.49	0.45
diabetes (HbA1c > 6.5%)	0.18	0.23	0.19	0.15

Figure 1. Density plots of coronary heart disease biomarkers in Costa Rica (CRELES, dashed lines) and the United States (NHANES, solid lines), men and women, age 60+



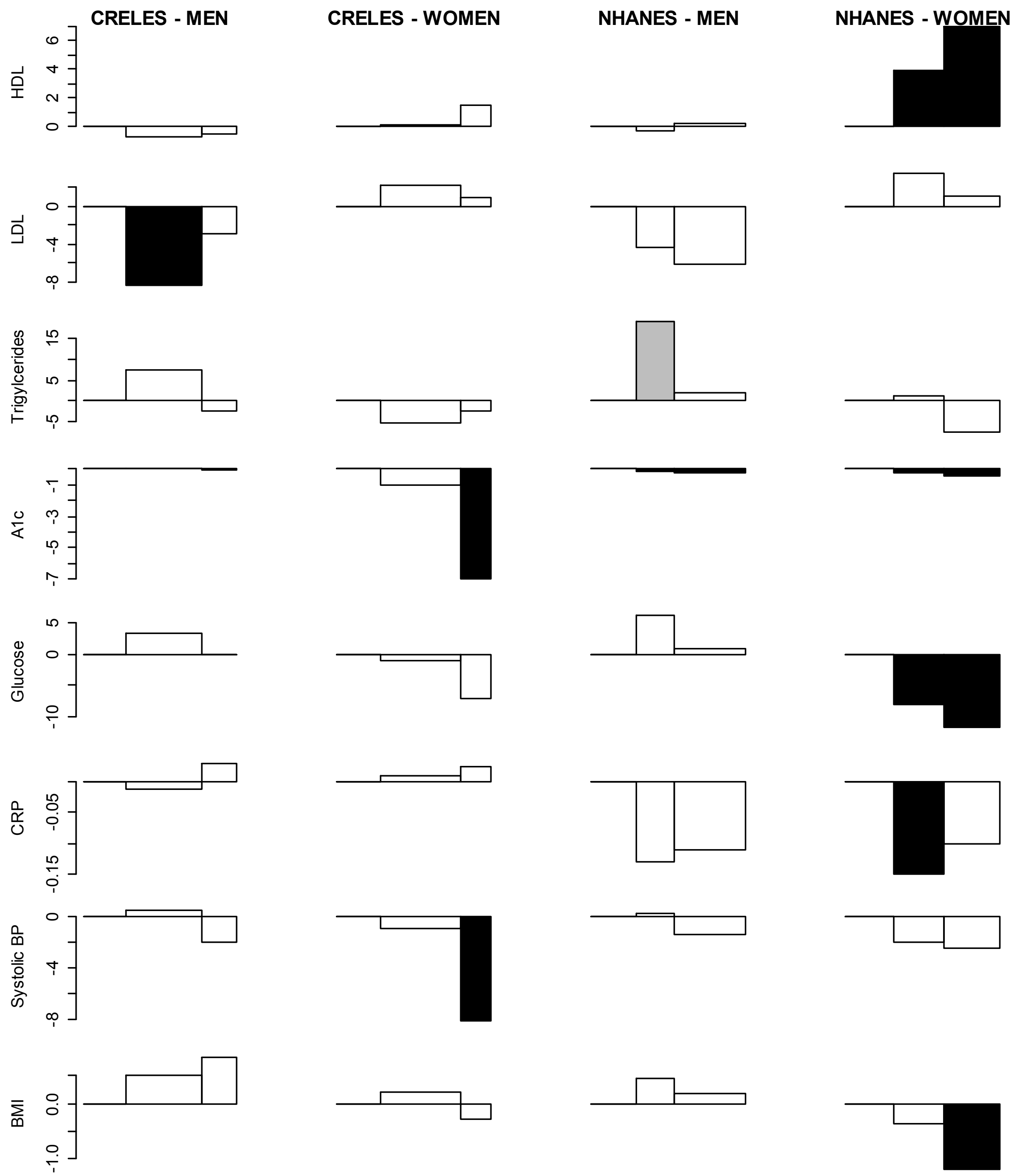
Vertical solid line indicates median in the United States, dashed vertical line indicates the median value in Costa Rica

Figure 2. Odds ratios of dichotomous anthropometric and health behavioral CHD risk factors by education in Costa Rica (CRELES) and the United States (NHANES), men and women, age 60+



Education differences plotted are odds ratios from logistic regression models controlling for age and age-squared. Bar widths are proportional to the relative size of the population in each category of education. Odds ratios statistically significantly different from the lowest education level are shaded (black if level is associated with lower risk of CHD, grey if level is associated with a higher risk of CHD).

Figure 3. Differences in levels of CHD biomarkers by education in Costa Rica (CRELES) and the United States (NHANES), men and women, age 60+



Education differences plotted are beta estimates from regression models controlling for age and age-squared, interpreted as the difference in the absolute difference in level of the biomarker compared to the lowest level of education. Bar widths are proportional to the relative size of the population in each category of education. Levels of biomarkers statistically significantly different from the levels for the lowest education level are shaded (black if level is associated with lower risk of CHD, grey if level is associated with a higher risk of CHD).

Appendix.

Table A1. Means and standard errors of biomarkers in Costa Rica and the United States, by gender, age 60+

	Costa Rica				United States			
	men		women		men		women	
Biomarker	Mean	SE	Mean	SE	Mean	SE	Mean	SE
HDL cholesterol (md/dl)	42.3	0.72	49.1	0.80	46.8	0.57	58.7	0.68
LDL cholesterol (mg/dl)	130	2.3	142	2.6	119	1.4	127	1.6
Triglycerides (mg/dl)	167	4.9	172	4.0	143	3.5	147	3.1
HbA1c (%)	5.70	0.055	5.98	0.080	5.86	0.027	5.76	0.027
Fasting glucose (mg/dl)	105	1.8	111	2.0	109	1.2	103	1.3
Systolic blood pressure (mm Hg)	145	0.91	146	0.71	134	0.59	141	0.84
C-reactive protein	0.558	0.047	0.583	0.027	0.496	0.027	0.56	0.020
Body mass index (kg/m2)	26.1	0.15	27.8	0.23	28.2	0.13	28.2	0.13

SE is standard error

Table A2. Odds ratios of dichotomous anthropometric and health behavioral CHD risk factors by education in Costa Rica (CRELES) and the United States (NHANES), men and women, age 60+

		Costa Rica				United States			
		men		Women		men		women	
	level of education	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds Ratio	95% CI
Health behaviors									
current Smoker	2	0.79	(0.52,1.2)	0.76	(0.41,1.4)	0.51	(0.35,0.74)	0.91	(0.59,1.40)
	3	0.82	(0.49,1.4)	1.0	(0.41,2.5)	0.42	(0.30,0.60)	0.62	(0.39,1.01)
ever smoked	2	0.78	(0.59,1.03)	0.56	(0.44,0.72)	0.87	(0.65,1.17)	1.05	(0.81,1.36)
	3	0.76	(0.50,1.2)	0.87	(0.61,1.2)	0.70	(0.55,0.89)	1.0	(0.75,1.34)
not active	2	0.95	(0.72,1.3)	0.76	(0.54,1.1)	0.87	(0.65,1.16)	1.0	(0.76,1.30)
	3	0.79	(0.52,1.2)	0.37	(0.23,0.59)	0.61	(0.46,0.80)	0.54	(0.43,0.67)
Diet									
high saturated fat	2	1.1	(0.68,1.7)	1.8	(1.0,3.0)	1.1	(0.69,1.6)	1.5	(0.63,3.4)
(>40 g/day)	3	1.8	(1.1,3.1)	2.2	(1.2,4.3)	1.4	(0.97,1.9)	1.3	(0.65,2.7)
high carbohydrate	2	0.93	(0.61,1.4)	1.3	(0.80,2.3	1.5	(0.92,2.6)	1.1	(0.37,3.2)
(>400 g/day)	3	0.91	(0.57,1.5)	1.7	(0.95,3.0)	1.7	(1.0,2.7)	1.9	(0.76,4.7)
high calorie	2	1.1	(0.7,1.7)	1.7	(0.82,3.7)	1.1	(0.69,1.8)	2.2	(0.64,7.6)
(>3000 kcal/day)	3	1.7	(0.9,2.9)	2.6	(1.2,5.5)	1.8	(1.2,2.7)	1.6	(0.49,5.0)
Anthropometric									
Obese	2	1.2	(0.8,1.7)	1.0	(0.76,1.3)	0.95	(0.72,1.27)	0.98	(0.75,1.27)
(BMI>30)	3	1.6	(1.0,2.6)	0.94	(0.63,1.4)	0.94	(0.76,1.17)	0.68	(0.52,0.89)
severely obese	2	0.96	(0.60,1.53)	0.79	(0.52,1.2)	0.81	(0.55,1.20)	0.92	(0.63,1.34)
(BMI>40)	3	0.93	(0.46,1.9)	0.97	(0.56,1.7)	0.89	(0.64,1.24)	0.71	(0.50,1.02)
large waist	2	1.2	(0.85,1.6)	0.78	(0.61,0.98)	0.95	(0.72,1.26)	0.82	(0.62,1.09
(>102 or 88 cm)	3	1.9	(1.2,3.1)	0.68	(0.48,0.96)	0.95	(0.74,1.21)	0.60	(0.46,0.78)

Table A3. Differences in levels of CHD biomarkers by education in Costa Rica (CRELES) and the United States (NHANES), men and women, age 60+

		Costa Rica				United States			
	level of	men		Women		men		women	
	education	Beta	95% CI	Beta	95% CI	Beta	95% CI	beta	95% CI
HDL cholesterol	2	-0.76	(-2.5,1.0)	0.060	(-1.6,1.7)	-0.33	(-2.7,2.1)	3.9	(1.2,6.6)
	3	-0.50	(-3.6,2.7)	1.5	(-1.3,4.4)	0.20	(-2.2,2.6)	7.0	(4.4,9.6)
LDL cholesterol	2	-8.3	(-16,-1.1)	2.2	(-2.6,7.1)	-4.4	(-12.4,3.7)	3.4	(-4.7,12)
	3	-2.9	(-12,6.3)	0.86	(-7.2,9.0)	-6.1	(-12.2,0.03)	1.0	(-5.3,7.3)
Triglycerides	2	7.5	(-8.2,23)	-5.4	(-17,6.0)	19	(0.24,38)	1.3	(-13,16)
	3	-2.6	(-27.3,22)	-2.4	(-23,18.4)	1.8	(-11,15)	-7.6	(-21,5.9)
Hemoglobin A1c	2	0.036	(-0.20,0.27)	-0.099	(-0.32,0.12)	-0.21	(-0.35,-0.07)	-0.3	(-0.42,-0.18)
	3	-0.046	(-0.35,0.26)	-0.43	(-0.74,-0.13)	-0.30	(-0.42,-0.18)	-0.4	(-0.55,-0.30)
Fasting glucose	2	3.4	(-4.8,12)	-1.0	(-8.5,6.5)	6.1	(-0.85,13)	-8.2	(-13.1,-3.3)
	3	-0.16	(-7.0,6.6)	-7.0	(-16,1.7)	0.93	(-6.4,8.2)	-11.6	(-17,-6.0)
C-reactive protein	2	-0.012	(-0.068,0.043)	0.0093	(-0.037,0.056)	-0.13	(-0.26,0.0)	-0.15	(-0.24,-0.06)
	3	0.031	(-0.045,0.11)	0.026	(-1.1,0.82)	-0.11	(-0.23,0.02)	-0.10	(-0.21,0.0)
Systolic blood Pressure	2	0.44	(-2.6,3.5)	-1.0	(-3.9,1.9)	0.20	(-2.1,2.5)	-2.0	(-4.6,0.62)
	3	-2.0	(-6.4,2.4)	-8.2	(-12,-3.8)	-1.5	(-3.6,0.61)	-2.5	(-5.7,0.67)
Body mass index	2	0.50	(-0.07,1.1)	0.20	(-0.70,1.1)	0.46	(-0.27,1.20)	-0.35	(-0.98,0.27)
	3	0.83	(-0.12,1.8)	-0.28	(-1.7,1.1)	0.18	(-0.44,0.79)	-1.18	(-1.9,-0.50)