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Surprising SES Gradients in Mortality, Health, and Biomarkers in a Latin American Population of Adults

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Background. To determine socioeconomic status (SES) gradients in the different dimensions of health among elderly Costa Ricans. Hypothesis: SES disparities in adult health are minimal in Costa Rican society.

Methods. Data from the Costa Rican Study on Longevity and Healthy Aging study: 8,000 elderly Costa Ricans to determine mortality in the period 2000–2007 and a subsample of 3,000 to determine prevalence of several health conditions and biomarkers from anthropometry and blood and urine specimens.

Results. The ultimate health indicator, mortality, as well as the metabolic syndrome, reveals that better educated and wealthier individuals are worse off. In contrast, quality of life–related measures such as functional and cognitive disabilities, physical frailty, and depression all clearly worsen with lower SES. Overall self-reported health (SRH) also shows a strong positive SES gradient. Traditional cardiovascular risk factors such as diabetes and cholesterol are not significantly related to SES, but hypertension and obesity are worse among high-SES individuals. Reflecting mixed SES gradients in behaviors, smoking and lack of exercise are more common among low SES, but high calorie diets are more common among high SES.

Conclusions. Negative modern behaviors among high-SES groups may be reversing cardiovascular risks across SES groups, hence reversing mortality risks. But negative SES gradients in healthy years of life persist.

Key Words: Aging—Biological markers—Costa Rica—Health—Mortality—Socioeconomic status.

VAST evidence from demographic and health surveys has shown that poorer health and higher mortality in children are clearly associated with lower socioeconomic status (SES) of parents everywhere in low- and high-income countries. In contrast, the evidence of an SES gradient in the health of adults in developing countries is scarce and conflicting. Particularly puzzling is the fact that subjective general health status measures have been found in some studies to have much larger SES gradients than more objectively measured health indicators. Crimmins (2005) discussed some hypotheses that could help explain these patterns, but there has been little analysis regarding which hypotheses are consistent with observed data.

This article further investigates this paradox using data from an ongoing longitudinal study of health and survival among elderly Costa Ricans (the Costa Rican Study on Longevity and Healthy Aging [CRELES]). CRELES has a rich array of health indicators, including subjective health, functional disability, mental health, frailty, and an array of objectively measured health conditions from blood and urine samples, as well as mortality data. In addition, CRELES collected data on various pathways through which these SES effects might be mediated as they influence different types of health indicators. In this article, we both document varying SES gradients across a wide range of well-defined health indicators and also estimate SES gradients in mediating behavior variables in order to elucidate what hypotheses may be most promising for further research.

Background

Analyses in developed countries have found SES and adult health to be significantly positively correlated—better health at higher SES (Seeman et al., 2008)—though gradients appear smaller at older ages than at earlier ages (Crimmins, 2005; Elo & Preston, 1996; Turra & Goldman, 2007). In developing countries, there has been much less study of older adult health differentials, partly due to the paucity of appropriate data until recent years. Now available surveys in elderly populations in Asia and Latin America do indeed appear to also show substantially poorer self-assessed health among the low educated (Palloni & McEniry, 2004; Zimmer, Natividad, Ofstedal, & Lin, 2002). However, the SES gradient in less subjective indicators is much less consistent. In Asia, surveys such as in Taiwan have found unclear relationships between SES and indicators of functional health, and SES differentials appear to even reverse for life-threatening measurements such as stroke, cancer, and diabetes (Zimmer et al., 2002). In contrast, Latin American surveys such as in Mexico find that the SES gradient persists for chronic conditions like diabetes, although with less strength than that observed in self-assessed health indicators (Palloni & McEniry, 2004). In both Asian and Latin American studies, socioeconomic differentials are often smaller than those observed in the high-income countries.

When studying mortality indicators, SES differentials for older adults are again not well understood in developing countries. A few recent studies have found that mortality by cardiovascular diseases (CVDs) and diabetes tends to be higher in the more developed areas of Costa Rica (Rosero-Bixby, 1996); similarly, a 17-year follow-up study in Costa Ricans showed no significant differences in survival by SES among older people (Rosero-Bixby, Dow, & Lacle, 2005). Another challenging result is the so called "Hispanic Paradox"; that is, the lower mortality of elderly Hispanics compared with the much more affluent White population in the United States (Elo, Turra, Kestenbaum, & Ferguson, 2004), which some argue may be partly due to cultural differences in health behaviors and psychosocial support. Hispanics also show significantly smaller SES differentials in mortality than Whites (Turra & Goldman, 2007). By contrast, Bangladesh data from a surveillance site shows the expected pattern of higher adult mortality at lower education (Hurt, Ronsmans, & Saha, 2004; Mostafa & Ginneken, 2000).

Various hypotheses have been suggested to explain different dimensions of the conflicting SES patterns in adult health. Some authors attribute to selection effects the weakening of SES differentials by age: that is, mortality eliminates the frailest individuals at early ages in groups with lower SES (Crimmins, 2005). But selection effects cannot easily explain the contrasting relationships across different domains of objective and subjectively reported health. These puzzles could be partly due to systematic biases by SES in subjective self-reports, but they also may reflect true differences in SES gradients across different domains of health. For example, it could be that low SES is associated with demanding physical labor across the life course that manifests in self-reported pain and mobility problems, whereas middle and higher income is associated with developed country lifestyles that elevate cardiovascular risks for mortality. Buffers to low SES may also operate differentially on different health domains, with national health insurance enabling low SES to buffer the ill effects of certain medically manageable cardiovascular risk factors, but with fewer buffers potentially available against the adverse effects of cumulative insults from low social and occupational status.

Costa Rica is well known as a country with outstanding health indicators. Its life expectancy at birth (78 years) is the second highest in the Americas (Canada is first), higher even than in the United States (World Bank, 2006). Broad explanations of Costa Rica's health achievements in the literature include the orientation of the government toward equity and social development, with large social investments being possible in part due to the absence of military expenditures, given that the 1949 constitution abolished the armed forces (Rosero-Bixby, 1991). Investments in education and the very high coverage of health insurance are often mentioned as key factors (Caldwell, 1986). The social security system, which is funded from deductions from payrolls and from contributions by employers and the government, is the provider of health insurance and health services with an almost universal coverage, especially for the elderly population. All workers in the formal sector and many workers in the informal sector contribute to the system and are entitled to health insurance that allows them and their families to receive free health care services and free medications at any hospital, clinic, or community health center. Additionally, the government provides free health insurance to poor people. According to the 2000 census, health insurance covers 82% of the population, including 9% destitute individuals whose insurance is paid by the government (Rosero-Bixby, 2004a). These percentages are higher among the elderly population. Provision of primary health care, particularly to remote or poor populations, has had a quantifiable impact on death rates (Rosero-Bixby, 2004b).

In economic terms, Costa Rica does not differ from the Latin American average. According to the World Bank (2006), its per capita income is about $4,600 per year, compared with the $3,600 average for Latin America. However, in terms of equity in income distribution, social security coverage, access to public health services and sanitation, labor laws, and protection of the environment, Costa Rica ranks among the highest in the continent. Costa Rica has a mixed economy with open markets and, at the same time, government control of key areas such as health, education, banking, energy, communications, and insurance (Mesa-Lago, 2000). The Human Development Index of the United Nations ranks Costa Rica 48th in the world and fourth in Latin America (after Chile, Argentina, and Uruguay).

This article follows a simple framework (Figure 1) to organize the different dimensions and indicators of health (Crimmins & Seeman, 2004). General health outcomes such as mortality and physical functioning are the end points of the framework. Proximate determinants very close to these outcomes are specific biological risk factors, usually measured by biomarkers such as blood pressure, obesity, and glucose levels. Then, one step back in the explanation hierarchy, there are health behaviors (diet, smoking, exercising) and health care services. This article analyzes the SES gradient for these three levels of health dimensions. Some demographic factors, such as age, sex, and marital status, are considered at the same hierarchical level and SES, and therefore their confounding effects must be controlled for.

Objective

The purpose of the article is to fill the breach in the literature regarding SES gradients in objectively measured adult health indicators in developing countries. Does the well-documented, strong connection of poor health and low SES among adults of rich countries and among children of developing countries persist in hard data for adults in middle-income countries like Costa Rica?

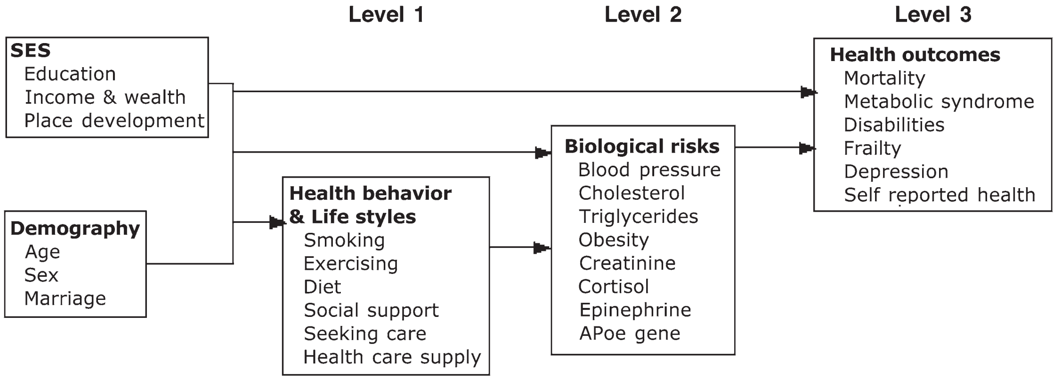

Figure 1. Framework for studying health indicators in three levels.

This analysis is of interest for multiple reasons. First, SES disparities in health outcomes are interesting in and of themselves and have received a great deal of public attention in other settings (such as in the United States or among children in Latin America). Yet they have rarely been documented in Latin American adult populations, primarily due to lack of data, except on a few select indicators. A key contribution of this article is the availability in CRELES of a wide range of both subjective and objective health measures, which we analyze within a uniform empirical framework, creating an unparalleled opportunity in Latin America to make SES gradient comparisons across them.

Second, the analysis is of interest because once we have established stylized facts about health disparities in this population, we can begin to evaluate existing hypotheses and generate new ones about the determinants of health patterns in this setting. There are many hypotheses about why health is typically worse in low SES populations. Similarly, many hypotheses have been advanced about how a middle-income country such as Costa Rica has been able to obtain exceptionally good population average health outcomes, such as higher life expectancy than the United States. These generally relate to models of the social determinants of population health: health care access, health behaviors, environmental health exposures, psychosocial stressors (inequality), and the ability to buffer against negative health shocks (social safety nets, social capital, and interpersonal ties). Although we do not formally test such hypotheses in this article, our analyses speak to the face validity of how some of these may or may not operate in Costa Rica. Because this is the first nationwide survey of adult health in Costa Rica, this article provides the first opportunity for beginning to evaluate such hypotheses.

The main hypothesis that we do test in this article is the provocative proposition that there is no SES gradient in Costa Rican adult health. This hypothesis is based on prior findings of no education or wealth gradients in Costa Rican mortality, from the only previous study on the subject, using data from a single peri-urban community (Rosero-Bixby et al., 2005). Observers have hypothesized that Costa Rica may have little SES gradient due to factors such as universal health insurance (which has allowed low SES groups similar access to care as high SES groups) in combination with Costa Rica perhaps being an unusually equitable society. For these factors to have been instrumental in minimizing SES gradients, however, it should be the case that SES gradients would be minimal across a wide range of health indicators beyond just mortality—which is exactly what our analyses test.

Data and Methods

Data for this analysis come from CRELES, an on-going longitudinal study of a nationally representative sample of about 9,000 adults aged 60 years and over and residing in Costa Rica in the year 2000, with oversampling of the oldest old and with an in-depth, longitudinal survey in a subsample of about 3,000 of them. For this analysis, we use mortality data from the computer follow-up of the sample in the national death registry from September 2000 to September 2006. The data on health (mostly prevalence of conditions) come from the first wave of interviews in the 3,000 subsample, conducted from November 2004 to September 2006. The mother sample of 9,000 individuals was randomly selected from the 2000 census database after stratification by 5-year age groups. Sampling fractions ranged from 1.1% among those born in 1941–1945 to 100% for those born before 1905. For the in-depth longitudinal survey, CRELES took from the mother sample a systematic subsample of 60 "health areas" (out of 102 for the whole country). This subsample included originally more than 4,000 individuals: 2,827 of them were finally interviewed. The subsample, which covers 59% of Costa Rican territory, yielded the following nonresponse rates: 19% of the individuals were deceased by the contact date, 18% were not found in the field, 2% moved to other addresses, 2% rejected the interview, and 2% remain as pending interviews after several visits (likely rejections). The individuals we did not find in the field originated mostly in the vagueness of the census address (and the lack of an accurate address system in Costa Rica), as well as from address changes during the approximately 5-year lag between the census and our visit. Thus, it would be unlikely that this group's SES patterns in health would be so different from the interviewed population so as to create significant selection effects that bias the estimated health–SES relationships. Among those interviewed, 95% provided a blood sample, 92% collected urine overnight, 91% had all anthropometric measures, and 24% required a proxy to answer the questionnaire.

All the data and specimens in the subsample were collected at the participants' homes, usually in two visits. In the first visit, participants provided informed consent and answered a 90-min questionnaire (including some mobility tests and two blood pressure measures) as well as a 10-min frequency of tracer food consumption questionnaire. In a second visit early the next day, fasting blood samples were collected by venipuncture: one EDTA tube (for 3–4 ml of whole blood) and two serum-separating tubes, with a clot activator (for 10–12 ml of blood, to obtain 4–6 ml of serum). In this visit, the field team also picked up a cooler containing 12-h overnight urine and took the anthropometric measures. All field data were collected using Personal Digital Assistants, also known as palm computers, with software applications developed by the Central American Population Center for this study.

A field team of five interviewers, two phlebotomists, and a supervisor collected the information and the blood and urine specimens using a continuous fieldwork design over a period of nearly 2 years. The field team received a 2-week training course that included standardized anthropometric measures. Several Costa Rican laboratories analyzed the blood and urine specimens, depending on the type of biomarker. All laboratories were certified by a national reference center of clinical chemistry, an agency under the Ministry of Health. In addition to the internal reliability tests that these laboratories must conduct as part of their quality control procedures, we conducted reliability analyses in subsamples of 20–40 specimens that were reanalyzed for each biomarker in a different laboratory. We report elsewhere the results of these reliability analyses, as well as some adjustments introduced to standardize measures across laboratories (Méndez-Chacón, Rosero-Bixby, Fernández-Rojas, & Barrantes-Jiménez, 2007).

We identified deaths of the 8,000 individuals in the original sample by computer follow-up in the national death registry during the period 2000–2007, using the unique identification number (the *cédula*) that all Costa Ricans have. Prior research has indicated that the death registry is virtually 100% complete (Rosero-Bixby, 2008). To further validate the registry quality, we were able to successfully match in the registry all of the several hundred deaths that we identified while attempting to contact individuals in the field for the household survey, thus finding no deaths missing from the registry.

Dependent Variables—Health Outcomes

We study three groups of dependent variables. All are coded as 0, 1 dichotomous indicators, with 1 measuring unfavorable conditions or events: (a) general health outcomes, (b) specific poor health conditions, including biomarkers, and (c) unhealthy lifestyles.

1. Seven general health outcomes:
    - Death in the period September 2000 to September 2007, in the sample of about 8,000 individuals. About 1,000 foreigners are excluded from the original mother sample of 9,000 because they do not have the personal identification ID that allows the computer follow-up to establish death and its date. The database was organized as a survival time file with left and right censoring. Individuals were observed 7 years or until death. The information on age is computed from the birth date in the birth record, avoiding the possibility of age-exaggeration errors.
    - Ordinal general SRH status. From the five possible answers, we took the two lowest (mala and regular) as defining poor SRH.
    - Functional disability when respondents have difficulties doing 50% or more of 14 activities and instrumental activities and instrumental activities of daily living (activities of daily living (ADLs)/instrumental activities of daily living (IADLs)), namely: walking on the streets, climbing stairs, pushing objects, raising an arm, crossing the bedroom on your feet, bathing, eating, going to bed, using the toilet, trimming toe nails, cooking, handling money, shopping, and taking medicines. Even though many studies distinguish basic, instrumental, and functional disabilities, we combine all these dimensions in a single indicator after checking that the Cronbach's alpha of the scale was an excellent .92 for the 14 items. This high alpha means that the items were not really different dimensions of disability. A person with basic disability (i.e., cannot use the toilet) is very likely to also have functional and instrumental disability (i.e., cannot cut toenails).
    - Physical frailty: respondents failing two or more out of five physical tests—grip strength with a dynamometer, pulmonary peak flow, standing up from a chair several times, picking an object up from the floor, and standing and walking 3 m.
    - Cognitive disability according to the Folstein (Folstein & Folstein, 1975) Mini-Mental State Examination (MMSE) (Quiroga, Albala, & Klaasen, 2004). We considered disabled those with less than 75% right answers of 15 items. The scale from adding the 15 items had an acceptable Cronbach's alpha of .72.

- Geriatric depression refers to individuals with nine or more out of 15 Yesavage symptoms of depression (Sheikh & Yesavage, 1986). It is not measured in participants who required a proxy (24%). The Cronbach's alpha of the scale was .85.
- Metabolic syndrome, which is a combination of five health conditions (abdominal girth, diabetes, triglycerides, High Density Lipoprotein (HDL) cholesterol, and high blood pressure) that increase a respondent's risk for CVD as defined by the International Diabetes Federation (IDF, 2006). The syndrome is present when individuals have high abdominal girth and at least two of the other four conditions.

2. Specific biological risk factors (Table 2 shows the cutoff points to define "at risk"). Some of them are components of the previous health outcomes. Most are components of the concept of allostatic load or biological dysregulation (Seeman et al., 2004). Details about specific indicators can be found in Crimmins and Seeman (2004).

2.1 CVD factors:
- Abdominal girth (waist >80 cm women, 94 cm men)
- Diabetes, controlled or not (glycosylated hemoglobin ≥6.5% or taking medicine)
- High blood pressure, controlled or not (diastolic >90 and systolic >140 mmHg in at least three out of four measurements or taking medicine)
- High triglycerides in fasting serum (≥50 mg/dl)
- High cholesterol ratio (total to HDL ≥5.92)

2.2 Various deregulation indicators (some are also related to CVD)
- Low creatinine clearance (≤44.64 mg/dl), an indicator of kidney function
- High cortisol (≥25.69 μg/g), indicator of activity in the hypothalamic pituitary (HPA) axis in response to stressors
- Low dehydroepiandrosterone sulfate (DHEA-S, ≤35 mg/dl). Antagonist to HPA activity
- High epinephrine (≥4.99 μg/g) in 12-h overnight urine. Indicator of neuroendocrine functioning in response to stress
- High norepinephrine (≥48 μg/g) in 12-h overnight urine. Similar to epinephrine
- High C-reactive protein (CRP) concentrations (≥10 mg/L). Indicator of inflammation, immunoresponse, and other conditions. Also a risk factor for CVD
- Weak handgrip strength (dynamometer ≤20 kg)

3. Unhealthy lifestyles
- Obesity (body mass index >30). (Note this is redundant with abdominal girth, which was included among CVD factors. It is included in this group as a summary indicator of unhealthy lifestyles regarding food consumption and physical activity.)
- Smoking current
- No regular exercise in last year
- No flu vaccine last year (a tracer of preventive care seeking)
- High-calorie diet (>3000 day)
- Low-calorie diet (<1500 day)
- High-carbohydrate diet (>400 g day)
- High-fat diet (>40 g day)

We have a total of 27 health indicators. Although there is some degree of overlap for several of them, this large number reflects the multidimensional character of the health concept and the complexities of measuring it. To facilitate interpretation and comparisons of results among the different outcomes, we opted for measuring them all with binary or dichotomous indicators of bad health. We recognize that there is some loss of information from translating continuous variables into dichotomous indicators. However, this loss is compensated by the gain in comparability and interpretability as well as by the gain of avoiding the distorting effects from extreme outlier values. Where possible, we dichotomized variables with cutoff values commonly used in clinical practice and the literature, including MMSE cognitive disability, Yesavage geriatric depression, triglycerides, CRP, obesity, abdominal obesity, and high- and low-calorie diet. There are also several indicators that are naturally dichotomous, including death, metabolic syndrome, diabetes, high blood pressure, smoking, lack of physical exercise, and flu vaccine. For the remaining 12 (out of 27) variables, our choice of cutoff values was driven by the observation of natural breaks in the distribution (SRH, functional disability, frailty, grip strength, and carbohydrate and fat intake) or was borrowed from the MacArthur study of healthy aging (Crimmins & Seeman, 2004; Seeman et al., 2004).

SES Variables

We examine the effect on health of three SES variables: place of residence, education, and household wealth. All three are categorized in three levels in order to ascertain the two sides of SES gradients: pertaining to a low-SES stratum or being a high-SES individual. For comparison purposes, these three variables are considered constant over time, and we are taking them as reported in the 2000 census, years prior to health measurement (note that mortality is studied for the period 2000–2007, prevalence of health conditions in the 2005–2006 survey, and the SES indicators are the same in both data sets).

1. Place of residence in 2000: (1) in the less developed lowlands, which include coastal regions at the Pacific Ocean and Caribbean, as well as the northern plains bordering Nicaragua and the Southern region bordering Panama; (2) in the rest of the highlands at the Central Valley, which includes some suburbs and satellite towns of San Jose; (3) in the more developed metropolitan

area of San Jose, the capital city. Although "place" is not an individual-level variable, there is a large literature considering the role of place in health disparities (e.g., Curtis and Rees-Jones, 1998). Our simple categorization distinguishing urban and these other settings is consistent with a long literature that has documented rural–urban differences in health in various settings.

2. Educational attainment in three naturally defined groups: (a) none, (b) elementary (one to six grades), and (c) some secondary (postelementary) school or higher. The effects of education are some of the most studied among SES variables, given that education is easy to measure, does not change in adult life, is easily comparable, and has a number of socioeconomic influences related to factors such as empowerment, income generation, information gathering, and health-seeking behavior (Elo & Preston, 1996; Hummer, Rogers, & Eberstein, 1998).
3. Household wealth in three groups: poor, middle, and rich. It is based on a simple count of 14 goods and conveniences in the household, ranging from no-dirt floors and having water connection and electricity to (at the high end) having a computer and a car. The wealth categories correspond to natural breaks in the distribution of the 0–14 count. Wealth is in essence income accumulation or permanent income and thus an indicator of economic well-being during long periods (Menchik, 1993).

Demographic and Other Controls

As far as possible, we present all health results adjusted by three demographic variables: (a) age (single year), (b) sex, and (c) marital status (whether or not currently married—including consensual unions). Age and marital status refer to the situation at the interview in all prevalence analyses. In the mortality analysis, age is time varying (each observation was split into single-age segments), and marital status is in the census interview in the year 2000. We also controlled in the regression models for the field worker who conducted the interview or took the anthropometric measures or other exams to correct potential interviewer and measurement biases (all data were gathered by seven field workers over a period of 2 years). Although all field workers received the same training, and visited the same areas, and the work load was more or less randomly distributed, it is always possible that idiosyncratic behavior of a specific field worker might introduce some measurement bias. For example, female examiners may tend to measure significantly lower values of waist circumference in female participants. Controlling for field worker in the multivariate analyses prevented the remote possibility that these biases were also correlated to SES of participants and thus were confounders of the relationship between health and SES.

Statistical Methods

To study mortality, we set the data as survival time (Statacorp, 2005), with entry date at September 2000 (3 months after the census interview to avoid likely biases in case some hospitalized or very sick individuals were not interviewed in the June census) and exit or right censoring at September 2007. We split observations into single-year segments (approximately seven segments per individual). Mortality rates were computed as the ratio of deaths to the exact count of person-years. We model some SES gradients in mortality with parametric hazard regression (streg command in Stata), assuming a Gompertz distribution (Hosmer & Lemeshow, 1999).

We used logistic regression models to estimate the SES gradients on health outcomes. The models control for demographic confounding effects as well as for the studied SES effects. To consider the possibility that age effects are nonlinear and differential by sex, we included in the models a quadratic term for age and an interaction term for age and sex. To compare odds ratios across models, we reanalyzed mortality using a logistic model with the probability of dying in each age of the observation period as the dependent variable. In this model, we used robust estimates that take into account the lack of independence of age segments within each individual.

The standard errors in the logistic models were estimated considering the clustering effect of selecting whole health areas in the subsample. This relaxed the assumption of independence among observations and required only that observations be independent across clusters. In some analyses, we assessed the significance of the joint effect of the three SES variables with a chi-square test of the improvement in the log-likelihood ratio resulting from including SES in the regression model.

Results

Table 1 shows the sizes and the composition by SES and demographic characteristics of the sample. The three categories by place of residence are about the same size. In contrast, education and wealth define a middle group with about two thirds of the observations. The low-end and high-end groups for these two variables comprise between 10% and 25% of observations. The distribution by age reflects oversampling of old-age groups by design. As usual in elderly populations, there are more women than men. About 50% of the sample is married or in consensual union.

Sample size varies depending on the studied outcome (Table 2). For studying mortality, our sample is more than 8,000 individuals or more than 50,000 person-years. For prevalence outcomes, the sample size is generally between 2,500 and 2,800. For some specific indicators, the size further diminishes by a few hundred because of noncompliance or refusals in blood sample and urine collection. The index of geriatric depression can be computed only

Table 1. Socioeconomic Status (SES) and Demographic Variables in the Mortality Sample and Prevalence Subsample

SES and Demographic Variables	Mortality Sample		Prevalence Subsample	
	N	%	*N*	%
Total	8,145	100	2,827	100
Residence				
Lowlands	2,653	33	1,097	39
Highlands	3,140	39	1,044	37
Metro San Jose	2,352	29	686	24
Education				
None	1,653	20	532	19
Elementary	5,286	65	1,901	67
Secondary+	1,206	15	394	14
Wealth				
Poor	1,989	24	674	24
Middle	5,249	64	1,881	66
Rich	907	11	272	10
Demographic controls				
Age (years)				
60–69	2,107	27	845	30
70–79	2,151	27	940	33
80–89	1,800	23	764	27
90+	1,803	23	278	10
Sex				
Women	4,289	53	1,534	54
Men	3,856	47	1,293	46
Marital status				
Nonmarried	4,058	50	1,414	50
Married	4,087	50	1,403	50

Note: Age at the middle of the mortality period (2000/2006) or at the interview in 2005/2006. Marital status at the interview for the prevalence subsample. Unweighted results.

for respondents who did not require a proxy in the interview (76%). We also have smaller sample size (about 1,600) for epinephrine and norepinephrine analyses because of degradation of stored urine samples.

Table 2 shows the observed values for the 27 health indicators by two large age brackets: 60–79 years and 80 or more years. Comparing the two age groups provides an initial snapshot of how indicators shift with age, although it does not allow us to separate out potential confounding from cohort-specific effects (e.g., younger cohorts adopting Western lifestyles that influence their health) as well as selection effects (e.g., smokers may die at younger ages, which means that they are underrepresented at older ages). Given that all are poor-health indicators, one would expect substantial increments with age (although evidence from other studies shows that some of these risk factors, such as obesity, cholesterol, and high blood pressure, may decline in late life as a result of other serious comorbidities). This is the case for the mortality rate with a sixfold increase—the largest in the table. Cognitive and functional disabilities show a fivefold increment, with age being the closest to mortality. SRH and depression change little with age, and metabolic syndrome actually moves in the opposite direction from the expected age effect—declining (which is a health improvement) 20% for older people. Health conditions that do not worsen, and even improve, with aging include the five components of metabolic syndrome: obesity, diabetes, high blood pressure, high cholesterol, and high triglycerides. These age trends could be a reflection of improved CV health with aging within each individual. Or they could simply come from changes in the composition of the population with aging in a selection in frailty process (Vaupel, Manton, & Stallard, 1979) that eliminates the frail and sick at earlier ages. The remaining biomarkers in the second panel of Table 2 deteriorate (increase) with age, although at rates substantially lower than mortality. Low creatinine clearance, a marker of kidney malfunction, and grip strength are the only ones with a substantial aging increase (ratio higher than 2).

Most behavioral or lifestyle indicators in the third panel of Table 2 improve (diminish) with age. Prevalence of smoking and obesity are less than half after age 80 than in the 60–79 age group, high-calorie diet diminishes by 40%, and high-carbohydrate diet by one third. The only behavioral deteriorations in the table are the lack of exercise and an increase in the proportion of individuals with a hypocaloric diet (probably because of loss of appetite).

Turning to the SES gradient issue, the exceptionally good health indicators of the Costa Rican population are by themselves a challenge to the notion of an inevitable SES gradient. Death rates of Costa Rican adults in the CRELES sample are lower than in the United States and not very different than in Japan, especially at higher ages (Figure 2), in spite of the substantially lower SES of the Latin American population measured by any traditional indicator such as education, income, or health expenditure. It is remarkable that a population with a per capita income that is one fifth of the United States' and per capita health expenditures that are one tenth of the United States' can have lower death rates than the United States. Life expectancy at age 60 implicit in the mortality rates in Figure 2 is 22.4 years for men and 24.8 for women in the Costa Rican sample. The corresponding values are 20.2 and 23.4 for the United States and 21.9 and 27.3 for Japan.

Often demographers have found that apparently low mortality at old ages in developing countries are solely an artifact of mismeasurement, particularly because of age exaggeration in census data that inflates the denominator and depletes the rates (Coale & Kisker, 1986; Preston, Elo, & Stewart, 1999). In the Costa Rican sample, however, age errors are very unlikely because we are using data on exact birthdates as they appear in civil registration records and on the universal identity card, the *cédula.* The possibility that we are finding low rates because of missing deaths in our computer follow-up is also remote because in the subsample of about 4,000 individuals CRELES visited, there was not a single case of a deceased person that was not also recorded in the national death registry computer follow-up. Furthermore, two other studies of old age mortality in Costa Rica have found similarly low rates (Rosero-Bixby, 2008; Rosero-Bixby et al., 2005).

Table 2. Health Outcomes and Specific Health Conditions in the Analysis by Age

Health Outcomes and Risk Conditions	N	Rate/Percentage 60–79	Rate/Percentage 80+	Ratio 80/60
General health outcomes				
Death rate (per 1,000)	8,144	21.4	128.9	6.02
Poor SRH	2,813	46.7	50.4	1.08
Functional disability (50%+ of 14 ADLs/IADLs)	2,822	7.3	37.4	5.11
Physical frailty (2+ out of five tests)	2,704	17.8	57.0	3.21
Cognitive disability (<75% of 15 MMSE items)	2,824	6.6	36.9	5.55
Geriatric depression (9+ out of 15 Yesavage items)	2,114	9.3	10.0	1.07
Metabolic syndrome	2,516	48.5	38.8	0.80
Specific poor-health markers				
Diabetes (glycosylated hemoglobin ≥6.5% or medicine)	2,618	24.5	16.9	0.69
High blood pressure (≥140/90 mmHg or medicine)	2,801	59.0	63.4	1.07
High triglycerides (≥150 mg/dl)	2,573	45.8	39.3	0.86
High cholesterol ratio (total/HDL ≥5.92)	2,654	29.3	23.6	0.81
Low creatinine clearance (≤44.64 mg/dl)	2,268	12.9	33.1	2.57
High cortisol (≥25.69 μg/g)	2,256	33.1	49.3	1.49
Low dehydroepiandrosterone sulfate (≤35 mg/dl)	2,621	38.6	59.2	1.53
High epinephrine (≥4.99 μg/g)	1,522	46.1	52.2	1.13
High norepinephrine (≥48 μg/g)	1,572	25.2	32.5	1.29
High C-reactive protein (≥10.0)	2,592	10.9	14.9	1.36
Weak grip strength (<20/30 kg M/F)	2,553	27.6	74.3	2.69
Unhealthy lifestyle				
Obese (BMI >30)	2,698	28.3	13.7	0.48
Abdominal girth (≥94/80 cm M/F)	2,632	69.3	62.2	0.90
Smoking current	2,827	10.8	5.4	0.50
No regular exercise in last year	2,827	65.5	86.4	1.32
No flu vaccine last year	2,794	54.0	32.6	0.60
High-calorie diet (>3000 day)	2,819	13.1	7.7	0.59
Low-calorie diet (<1500 day)	2,819	15.3	21.6	1.42
High-carbohydrate diet (>400 g day)	2,819	16.4	10.2	0.62
High-fat diet (>40 g day)	2,819	14.2	12.3	0.87

Notes: Rate or percentage computed considering sampling weights.

SRH = self-rated health; ADL/IADL = activities of daily living/instrumental activities of daily living; MMSE = Mini Mental State Examination; HDL = high-density lipoprotein; BMI = body mass index.

Within Costa Rica, there is not a clear SES gradient in adult mortality or, if anything, the gradient is contrary to expectations. Table 3 and Figure 3 show that in our sample, there are slight increases in mortality with higher levels of education and wealth, net of other influences, and the least developed lowlands have lower mortality than the more developed highlands. Only the more developed capital city behaves according to expectations, showing lower mortality, although by a small margin.

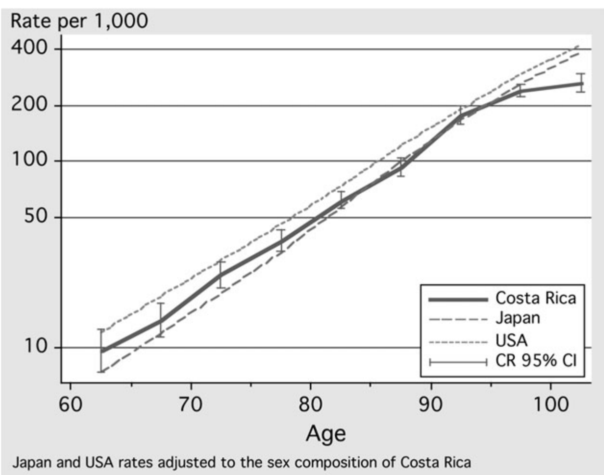

Figure 2. Age-specific death rates. Costa Rica sample, Japan, and United States.

These mortality gradients contrast dramatically with the observed differentials by SRH in Table 3 and Figure 3. The affluent and those with high school education self-report 40% less poor health than the national population. The poor, those with no formal education, and those living in the lowlands report 20% more poor health than the national average. This contradiction between mortality and SRH is the motivation for the adjective of "surprising" SES gradients in this article's title.

In four other health outcomes, SES effects are similar to those observed for SRH (Table 3). High-SES individuals are less affected by functional, physical, and cognitive disabilities, or by depression. However, metabolic syndrome (a multidimensional risk factor for CVD) behaves more like mortality with no significant SES differentials. There are also peculiarities of metabolic syndrome variation with age (no gradient), sex (much lower in men), and conjugal status (higher among the married), but these are not the focus of this article. Given the enormous importance of CVD in adult mortality (nearly half of old-age deaths are

Table 3. Socioeconomic Status (SES) Gradients in Five Health Outcomes as Estimated by Logistic Regression Odds Ratios

Explanatory Variables	Death	Poor SRH	Functional Disability	Physical Frailty	Cognitive Disability	Geriatric Depression	Metabolic Syndrome
Residence							
Lowlands	0.90*	1.50*	0.75*	0.51*	0.76*	1.60*	0.88
Highlands	1	1	1	1	1	1	1
Metro San Jose	0.89*	0.85	0.82	0.87	0.71*	1.15	1.20
Education							
None	0.96	1.18	1.36*	1.18	2.30*	1.05	0.78*
Elementary	1	1	1	1	1	1	1
High school+	1.13*	0.42*	0.56*	0.58*	0.52*	0.78	0.88
Wealth status							
Low wealth	0.97	1.38*	1.48*	1.45*	1.31*	1.51*	0.77*
Medium	1	1	1	1	1	1	1
High wealth	1.06	0.67*	1.03	0.67*	0.93	0.73	0.93
Control variables							
Age (in years)	1.11*	1.02*	1.12*	1.12*	1.11*	0.97*	0.99
Age square	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Men	1.51*	0.76*	0.69*	0.20*	0.94	0.48*	0.27*
Age × Men	1.00	1.00	0.99	1.00	0.99	1.03	1.00
Married	0.90*	1.24*	1.00	0.91	0.72*	0.81	1.27*
Field workers							
G.S.		1	1	1	1	1	1
J.V.		0.76	1.16	1.99*	1.11	1.54	1.01
M.G.		0.91	1.73*	1.35	2.63*	1.53*	0.93
M.R.		0.79*	1.15	1.78*	0.73	1.45	0.91
M.A.		1.15	1.20	1.51	1.23	1.78	0.85
J.P.				2.09*			1.16
J.M.				1.18			0.75
Other				1.31			0.79
Goodness of fit							
Pseudo R^2 full model	.138*	.061*	.266*	.289*	.293*	.043*	.086*
LR χ^2 (six SES)	13.7*	180.2*	34.0*	55.3*	77.4*	23.7*	22.6*

Notes: LR χ^2 is the log-likelihood ratio chi square of including the six SES variables in the model.
*Significant at $p < .05$.

cardiovascular related in Costa Rica), this CVD risk factor helps explain the observed lack of SES gradients in overall mortality.

To more finely explore the SES gradients in 20 intermediate health conditions, Table 4 summarizes the results obtained from a series of logistic regressions. With a regression model for each health condition, We first estimated the net effects of the three SES variables and whether there was a significant joint effect of including the three variables in each model. In one third of the health indicators in the table (6 out of 20), there are no significant joint SES effects. In the rest, the SES gradient sometimes behaves as expected with below-one odds ratio for the high-SES categories and above one for the low SES. However, the reverse also is present in several indicators, such as obesity and triglycerides. To make things more complicated, there are several cases of a curvilinear SES gradient, in which the middle-SES group is the worse off. That is the case for triglycerides by wealth; cholesterol and abdominal girth by education; and DHEA-S, epinephrine, and norepinephrine by place of residence.

Figure 4 summarizes the large amount of information presented in Tables 3 and 4. With a logistic regression model for each health condition, the net effect of the three high-SES characteristics (metro San Jose, high school education, and rich wealth). We then summarized the three odds ratios by computing the one that would correspond to an individual with simultaneously the three high-SES characteristics; that is, by multiplication of the three odds ratios, and (except in six cases as described subsequently) we report this product in Figure 4. Given that this procedure presumes no interactions among the three SES variables, we also tested models with the triple interaction of the three low-SES indicators and with the triple interaction of the three high-SES indicators (these extreme groups of all low SES and all high SES each represent only 4% of the sample). In the six (out of 54) regression models where these interactions proved significant, we instead report in Figure 4 an odds ratio that includes this triple interaction, rather than the previously described product of the odds ratios in the uninteracted model. In five of the six significant triple-interacted models, results were insensitive to the choice of method. Figure 4 shows these hypothetical odds ratios, sorted descending by the low-SES effect, which conversely results in approximately ascending sorting by the high-SES effects. Figures below 1 (dots at the left) denote good health; that is, the risk of suffering the condition is lower in the group with respect to the rest of the population.

If the SES gradient behaved as expected in Figure 4, the high-SES triangles should line up at the left of the

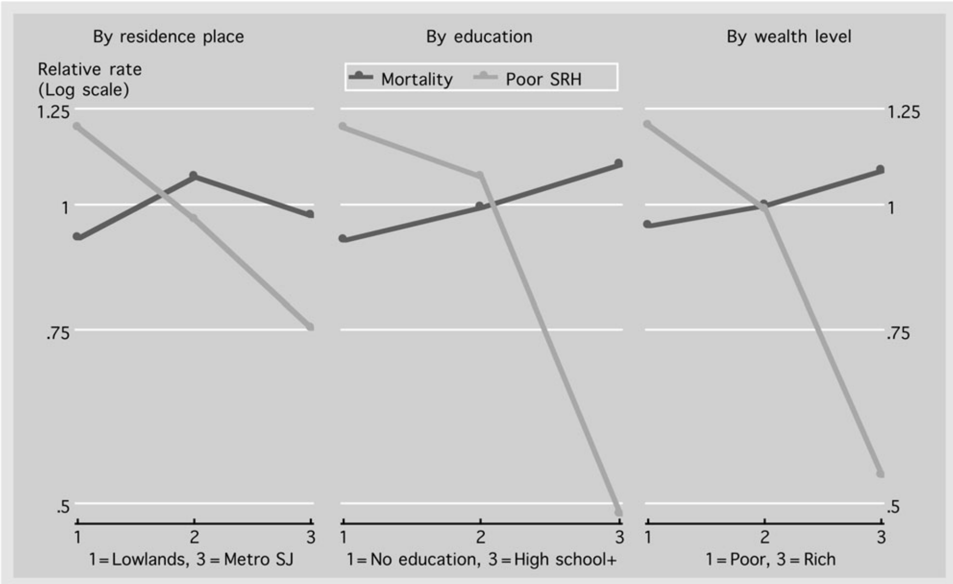

Figure 3. Socioeconomic status (SES) gradients in mortality and poor self-rated health (SRH). Costa Rican elderly. Rates or proportions relative to total population, controlled for age, sex, and marital status with regression: logistic for proportions and Gompertz hazard for rates.

figure and the low-SES circles should be at the right. Reality, as depicted by this Costa Rican sample, is far from that expected gradient. There are three groups in our 27 health indicators: (a) 11 health indicators with the expected gradient of better health at high SES, (b) 9 health conditions, including death, in which low-SES individuals are better off, and (3) 7 indicators with no significant SES effects.

The expected SES gradient (Figure 4) occurs in five of our seven health outcomes (SRH; cognitive, functional,

Table 4. Socioeconomic Status (SES) Gradients in Intermediate Health Indicators as Estimated by Logistic Regression Odds Ratios

Poor Health Indicators	Lowlands	Metro San Jose	No School	High School	Low Wealth	High Wealth	Pseudo R^2 Full	LR χ^2 (six SES)
Poor-health biomarkers								
Diabetes	0.85	1.02	1.01	0.91	0.81	0.86	0.027*	7.3
High blood pressure	0.80*	1.14	0.90	0.89	0.84	0.84	0.029*	21.2*
High triglycerides	0.91	1.14	0.78*	1.01	0.80*	0.76	0.021*	22.2*
High cholesterol ratio	0.81	1.18	0.68*	0.83	1.10	0.90	0.020*	21.3*
Low creatinine clearance	0.97	1.29	1.42*	1.30	1.05	1.43	0.089*	17.5*
High cortisol	0.83	0.86	1.21	1.01	1.04	0.85	0.033*	7.1
Low dehydroepiandrosterone sulfate	0.65*	0.74*	0.93	1.10	0.83	1.16	0.115*	31.8*
High epinephrine	0.58*	0.50*	0.79	0.84	1.03	0.83	0.026*	32.1*
High norepinephrine	0.45*	0.26*	1.23	0.91	1.10	1.20	0.069*	75.1*
High C-reactive protein	1.02	1.16	0.94	0.73	1.10	0.92	0.019*	4.0
Weak grip strength	0.77*	1.01	1.11	0.70*	1.41*	0.76	0.204*	26.9*
Unhealthy lifestyles								
Obese (BMI >30)	1.10	1.28*	0.85	0.85	0.70*	1.08	0.080*	16.6*
Abdominal girth	0.86	1.09	0.78*	0.85	0.72*	1.36	0.167*	32.0*
Smoking current	0.79	1.15	1.33	0.95	1.85*	0.59	0.123*	24.0*
No regular exercise	1.13	1.38	1.24	0.57*	0.85	0.75*	0.102*	34.3*
No flu vaccine last year	1.08	1.53*	0.82	1.01	1.15	1.13	0.067*	22.8*
High-calorie diet	1.30	1.33*	0.88	1.30	0.69	1.20	0.061*	15.6*
Low-calorie diet	0.83	0.86	1.69*	0.87	1.29	0.95	0.064*	30.7*
High-carbohydrate diet	1.22	1.09	1.08	0.64	1.07	0.72	0.445*	8.7
High-fat diet	1.03	0.99	0.90	1.28	0.75	0.95	0.234*	6.0

Notes: These results are controlled for by age, age square, sex, Age × Sex interaction, marital status, and field worker. Diet indicators also controlled for knee height, and carbohydrates and fat are controlled for calorie intake. The reference groups for the three SES variables are highlands, grade school, and intermediate wealth, respectively. The pseudo R^2 measures the goodness of fit of the full, unrestricted model. LR χ^2 is the log-likelihood ratio chi square including the six SES variables in the model.

*Significant at $p < .05$. BMI = body mass index.

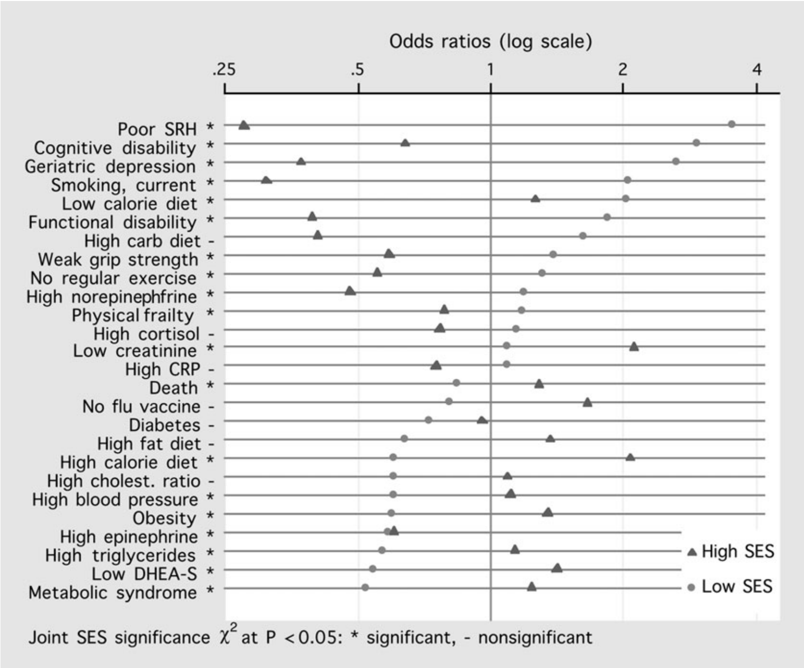

Figure 4. Poor-health indicators odds ratio prevalence in high-socioeconomic status (SES) and low-SES individuals. See text for method to calculate odds ratios from models controlling for age, sex, and marital status with logistic regression. High SES are wealthy metro San Jose residents with postprimary education; low SES are poor lowland residents with no education. SRH = self-rated health; CRP = C-reactive protein; DHEA-S = Dehydroepiandrosterone sulfate

and physical disability; and depression), as well as in just two biomarkers (norepinephrine and grip strength) and two behavioral conditions (smoking and lack of exercise).

Counterbalancing the aforementioned health indicators, there are 10 conditions in which low-SES individuals do significantly better than high-SES groups: death, creatinine clearance, high-calorie diet, high blood pressure, obesity, high epinephrine, triglycerides, and low DHEA-S levels, as well as the metabolic syndrome and its main component: abdominal girth. The pattern of the flu vaccine (although marginally nonsignificant) is on line with earlier findings that the Costa Rican primary health care system equalizes access to health in all SES levels. It has been shown, for example, that there is a lower coverage of immunization among children of more affluent mothers (Chen-Mok et al., 2001). It is interesting to note that in several CVD risk factors, the SES disadvantaged groups do better, including triglycerides, cholesterol ratio, high blood pressure, diabetes, and fatty diet, although some of the effects are not significant.

Discussion

Rich data for elderly Costa Ricans from the CRELES project, which include a 6-year follow-up of a sample of 8,000 as well as biomarkers in a subsample of about 2,500, show puzzling SES gradients in 26 health indicators. Disadvantaged groups in terms of education, wealth, and residence show steep health deficits in SRH as well as in indicators of functionality and physical and mental fitness. In contrast, in the single most important health outcome, mortality, there are no significant SES differentials; on the contrary, there are even hints that low-SES groups might be better off. Metabolic syndrome, a risk factor for CVD, shows a similar pattern as mortality.

The direct relationship between SES and mortality found in these data may occur only in the elderly population under study (60 years and over). The usual inverse relationship may persist in younger ages, which were not included in the analyzed sample.

This study intentionally considers a large number of health indicators to reflect the multidimensional character of the health concept. The results show that these multiple dimensions of health do not behave in a monolithic way. SES, and aging as well, generates very diverse responses in different aspects of health. Cognitive impairment, for example, is substantially higher at older age and low SES (although the strong negative association with education may be exaggerated by a cultural bias in the Mini Mental test). Similarly, geriatric depression in our data is one of the most clear correlates with low SES, but it changes little with age (though the latter may be due to the large proportion of missing responses among the oldest old needing a proxy in the interview). Our stress-related biomarkers—epinephrine and norepinephrine—also show an advantage for the affluent and educated.

Risk factors for CVD show more nuanced and mixed patterns by SES. These Costa Rican data show that socioeconomically disadvantaged populations have lower prevalence of obesity, hypercholesterolemia, triglycerides, hypertension, and hyperglycemia. The changing association between SES and CVD merits careful monitoring in countries like Costa Rica. DHEA-S, a hormone some consider a marker of aging, also shows a more favorable situation in low-SES individuals.

Behavioral or lifestyle risk factors also show divergent patterns by SES. Smoking, sedentariness, and high-carbohydrate diets are less prevalent among the better off. But obesity, high fat, and high-calorie diets diminish consistently and substantially with SES. Interestingly, there are no negative SES gradients in our indicator of access to preventive care: having had the flu vaccine. This is an indication of an important attribute of the public primary health care system in Costa Rica—its coverage of the lower strata of society to equalize access to health care (Rosero-Bixby, 2004a).

Viewing the diet-related biomarkers in conjunction with the dietary intake data, we can hypothesize that worse nutritional behaviors among higher SES groups may be playing a significant role in driving the worse CVD risks, and hence higher mortality, among the higher SES. Moreover, the low-calorie diet of low-SES individuals might be a protective factor because it has been shown that dietary caloric restriction slows ageing in other species (Roth et al., 2002). This raises the question of what the time path has been and will be of SES gradients in nutritional behaviors. A substantial literature has documented the transition of middle-income countries from positive SES–obesity relationships to negative ones as countries develop (e.g., Monteiro, Moura, Conde, & Popkin, 2004); whereas countries such as Mexico appear to have already moved through this nutritional transition, Costa Rica appears to lag. It will be useful for future work to document the history of this SES–nutrition relationship in Costa Rica, as well as to closely track its evolution, as this may have major implications for whether Costa Rica's mortality gradient reverses in the future to the more usual negative relationship with SES.

For the broader set of health indicators examined, however, we do not know whether the findings in this article are unique to Costa Rica or whether they are common in other middle- and low-income countries. Reliable data to study SES gradients in adult mortality and in "hard" health indicators are rare. The more available "soft" data on SRH show the steep SES gradient observed in this article. However, this article shows that one cannot jump from there to conclusions on other health outcomes. More research is clearly needed in adult health outside the developed countries.

Costa Rica is a special case of exceptional achievements in health and social development in spite of a weak economy. Two decades ago it was included, along with Sri Lanka, Kerala, China, and Cuba, among the world showcases of "good health at low cost" (Halstead, Walsh, & Warren, 1985), and it has remained in that category. Some have explained the country's longevity achievements with its investments in education and health insurance (Caldwell, 1986). However, those can only be part of the explanation because even those with no education are doing fine in important aspects of health, including health dimensions not clearly influenced by medical care access. It could even be that if a poor or traditional society completes the first stage of the epidemiologic transition by controlling communicable diseases, some traditional lifestyles can protect it from health problems like obesity and take it to better general health indicators such as lower mortality. This evidence of success is tempered, however, by our strong evidence of a significant SES gradient in functional and mental health indicators, suggesting that disability-free life expectancy is indeed worse among more vulnerable adults even in Costa Rica.

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References

Caldwell, J. C. (1986). Routes to low mortality in poor countries. *Population and Development Review*, *12(2)*, 171–220.

Chen-Mok, M., Rosero-Bixby, L., Brenes-Camacho, G., León-Solís, M., Gonzalez-Lutz, M. I., & Venegas-Pissa, J. C. (2001). *Salud reproductiva y migración nicaragüense en Costa Rica, 1999–2000: Resultados de una encuesta nacional de salud reproductiva*. San José: Universidad de Costa Rica.

Coale, A. J., & Kisker, E. E. (1986). Mortality crossovers: Reality or bad data. *Population Studies*, *40(3)*, 389–401.

Crimmins, E. M. (2005). Socioeconomic differentials in mortality and health at the older ages. *Genus*, *LXI(1)*, 163–178.

Crimmins, E. M., & Seeman, T. (2004). Integrating biology into the study of health disparities (in health and socioeconomic status). *Population and Development Review*, 30 (Supplement: Aging, Health, and Public Policy), 89–107.

Curtis, S., & Rees-Jones, I. (1998). Is there a place for geography in the analysis of health inequality? *Sociology of Health and Illness*, *20*, 645–672.

Elo, I. T., & Preston, S. H. (1996). Educational differentials in mortality: United States, 1979–85. *Social Science & Medicine*, *42(1)*, 47–57.
Elo, I. T., Turra, C. M., Kestenbaum, B., & Ferguson, B. R. (2004). Mortality among elderly Hispanics in the United States. *Demography*, *41*, 109–120.
Folstein, M. E., & Folstein, S. E. (1975). Mini-Mental State. A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–195.
Halstead, S. B., Walsh, J. A., & Warren, K. S. (1985). Good health at low cost. *Proceedings of a Conference Held at the Bellagio Conference Center*. New York: The Rockefeller Foundation.
Hosmer, D. W., & Lemeshow, S. (1999). *Applied survival analysis*. New York: John Wiley & Sons.
Hummer, R. A., Rogers, R. G., & Eberstein, I. W. (1998). Sociodemographic differentials in adult mortality: A review of analytic approaches. *Population and Development Review*, *24(3)*, 553–578.
Hurt, L. S., Ronsmans, C., & Saha, S. (2004). Effects of education and other socioeconomic factors on middle age mortality in rural Bangladesh. *Journal of Epidemiology and Community Health*, *58*, 315–320.
International Diabetes Federation (2006). The IDF consensus worldwide definition of the metabolic syndrome. Brussels, Belgium: IDF.
Menchik, P. L. (1993). Economic status as a determinant of mortality among black and white older men: Does poverty kill? *Population Studies*, *47(3)*, 427–436.
Méndez-Chacón, E., Rosero-Bixby, L., Fernández-Rojas, X., & Barrantes-Jiménez, K. (2007). Comparación de los resultados de pruebas de laboratorio seleccionadas de un estudio poblacional de adultos mayores de Costa Rica. *Población y Salud en Mesoamérica*, 5(1), Article No. 4, Retrieved on August 10, 2008 from http://ccp.ucr.ac.cr/revista/index.htm.
Mesa-Lago, C. (2000). *Market, socialist, and mixed economies: Comparative policy and performance—Chile, Cuba, and Costa Rica*. Baltimore, MD: Johns Hopkins University Press.
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*, 940–946.
Mostafa, G., & Ginneken, J. K. (2000). Trends in and determinants of mortality in the elderly population of Matlab, Bangladesh. *Social Science & Medicine*, *50(6)*, 763–771.
Palloni, A., & McEniry, M. (2006). Aging and health status of elderly in Latin America and the Caribbean. *Journal of Cross Cultural gerontology*, *22*:263–285.
Preston, S. H., Elo, I. T., & Stewart, Q. (1999). Effects of age misreporting on mortality estimates at older ages. *Population Studies*, *53(2)*, 165–177.
Quiroga, P., Albala, C., & Klaasen, G. (2004). Validación de un test de tamizaje para el diagnóstico de demencia asociada a edad, en Chile. *Revista Médica de Chile*, *132(4)*, 467–478.
Rosero-Bixby, L. (1991). Socioeconomic development, health interventions, and mortality decline in Costa Rica. *Scandinavian Journal of Social Medicine (Suppl. 46)*, 33–42.
Rosero-Bixby, L. (1996). The decline in adult mortality in Costa Rica. In J. Chackiel, L. Ruzicka, & I. Timaeus (Eds.), *Adult mortality in Latin America* (pp. 166–196). Oxford, UK: Clarendon Press.
Rosero-Bixby, L. (2004a). Supply and access to health services in Costa Rica 2000: A GIS-based study. *Social Science and Medicine*, *58*, 1271–1284.
Rosero-Bixby, L. (2004b). Evaluación del impacto de la reforma del sector salud en Costa Rica. *Revista Panamericana de Salud Pública*, *15(2)*, 94–103.
Rosero-Bixby, L. (2008). The exceptionally high life expectancy of Costa Rican nonagenarians. *Demography*, *45(3)*:673–691.
Rosero-Bixby, L., Dow, W. H., & Lacle, A. (2005). Insurance and other determinants of elderly longevity in a Costa Rican panel. *Journal of Biosocial Sciences*, *37(6)*, 705–720.
Roth, G. S., Lane, M. A., Ingram, D. K., Mattison, J. A., Elahi, D., Tobin, J. D., Muller, D., & Metter, E. J. (2002). Biomarkers of caloric restriction may predict longevity in humans. *Science*, *297*, 811.
Seeman, T. E., Crimmins, E. M., Huang, M. H., Singer, B., Bucur, A., Gruenewald, T., Berkman, L. F., & Reuben, D. B. (2004). Cumulative biological risk and socioeconomic differences in mortality: MacArthur studuies of successful aging. *Social Science & Medicine*, *58(10)*, 1985–1997.
Seeman, T., Merkin, S. M., Crimmins, E. M., 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.
Sheikh, J. L., & Yesavage, J. A. (1986). *Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. Clinical gerontology: A guide to assessment and intervention*. New York: Haworth Press.
Statacorp. (2005). *Stata statistical software: Release 9.0*. College Station, TX: Stata Corporation.
Turra, C. M., & Goldman, N. (2007). Socioeconomic differences in mortality among U.S. adults: Insights into the Hispanic Paradox. *Journals of Gerontology: Social Sciences*, *62(3)*, S184–S192.
Vaupel, J. W., Manton, K. G., & Stallard, E. (1979). The impact of heterogeneity in individual frailty on the dynamics of mortality. *Demography*, *16(3)*, 439–454.
World Bank. (2006). *World development report 2006*. New York: Oxford University Press.
Zimmer, Z., Natividad, J. N., Ofstedal, M. B., & Lin, H. S. (2002). Physical and mental health of the elderly. In A. Hermalin (Ed.), *The well-being of the elderly in Asia* (pp. 362–411). Ann Arbor: University of Michigan Press.

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