J. biosoc. Sci. (2005) **37**, 705–720

doi:10.1017/S0021932004006996

INSURANCE AND OTHER SOCIOECONOMIC DETERMINANTS OF ELDERLY LONGEVITY IN A COSTA RICAN PANEL

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Summary. Official figures show that life expectancy in Costa Rica is longer than in the United States (US), in spite of the fact that *per capita* health expenditure is only one-tenth that of the US. To check whether this is for real and to explore some of its determinants, 900 Costa Ricans aged 60+ were followed from 1984 to 2001. Follow-up household visits were made, deaths were tracked in the national death registry, and survival status in the voting registry was double-checked. In addition, the survivors were contacted in 2002. Two-thirds of the panel had died by December 2001. Kaplan–Meier curves, life tables and Cox regression were used to analyse the panel's survival. Mortality in the panel was slightly higher than the Costa Rican average and similar to that in the US, confirming the exceptional longevity of Costa Ricans. Survival was substantially lower among unmarried men and individuals with limited autonomy at the beginning of the study. The effect of socioeconomic status is weak. Insurance effects seem to be confounded by selection biases.

Introduction

Life expectancy in Costa Rica is almost 78 years, exactly the same as in the United States and Western Europe. It is the highest in Latin America, followed by Chile (77 years) and Cuba (76 years) (Population Reference Bureau, 2002). Among adults, Costa Rican males in fact have higher age-60 life expectancy than even white males in the US (Rosero-Bixby *et al.*, 2004). This is despite Costa Rica having a *per capita* GNP of less than one-fifth that of the US (by purchasing power parity), and Costa Rica having *per capita* health expenditure of about one-tenth the United States (Pan American Health Organization, 2002). Is this for real? If so, how can this be? In fact, very little is known about longevity of the elderly in developing countries, much less longevity differentials and determinants.

Preliminary studies comparing causes of death have shown that the high life expectancy of Costa Rican adults comes mainly from a lower incidence of cardiovascular diseases, lung cancer and breast cancer. By contrast, Costa Ricans are at considerable disadvantage regarding diabetes mellitus, stomach cancer and cervical cancer (Rosero-Bixby, 2002). Little is known about the country's socioeconomic influences on adult health and survival. Some of these influences appear weak or even contradictory to the expected negative mortality gradient with higher socioeconomic status (Rosero-Bixby, 1995; Rosero-Bixby *et al*., 2004). External observers have attributed the high life expectancy of Costa Ricans to the effects of high levels of education, a strong primary care focus in the health system, and the role of a national health insurance fund in eliminating financial barriers to health care access (Caldwell, 1986).

One policy tool for improving health and ameliorating socioeconomic differentials is increasing access to health care through promotion of health insurance. However, the health benefits of health insurance have proven difficult to document, in part because of poor methodological designs. In a recent survey of dozens of studies relating insurance to health in the United States, Levy & Meltzer (2001) found only a handful with designs adequate for inferring causality. Based on those, they conclude that health benefits of insurance appear quite small, although there did appear to be some significant effects for certain vulnerable low-income groups (Brook *et al*., 1984). Other reliable studies identified by Levy & Meltzer (2001) included natural experiment analyses of Medicaid expansions, which again indicated that insurance might be relevant for low-income groups (Currie *et al*., 1995; Currie & Gruber, 1996). In developing countries, where fewer individuals are currently covered by insurance, even less is known about the effects of insurance expansions on health and longevity. In Costa Rica, ecological- and individual-level studies have shown moderate effects of the health insurance expansion of the 1970s upon child mortality (Dow & Schmeer, 2003; Dow *et al*., 2003).

Conceptually, insurance could be expected to improve health via reducing financial barriers to health care, and considerable evidence has documented the price-responsiveness of health care utilization across developed (Manning *et al*., 1987) and developing countries (Gertler & van der Gaag, 1990). Less established is whether insurance is able to induce the type of health care that could reduce premature death. It is possible that increased insurance might only improve access to acute curative care, comparing poorly to more effective interventions that increase preventive health care. If, for example, insurance leads to improved diabetes control, hypertension control and more cancer screening, then it is plausible that longevity could be measurably improved.

Mesa-Lago (1985) documented the evolution of national health insurance in Costa Rica and its notable expansion in the 1970s, originating in the 1971 National Health Plan and a new law that established the universal cover of the insurance system. Before this law, only wage-earners in the formal sector, and their families, were covered by the system (which was provided by the social security fund or CCSS). The new policy included provisions for covering self-employed and agriculture workers and their families. It also established a 'non-contributive' insurance system, which allowed central government to pay the insurance costs of the destitute. Census data show that the cover of health insurance in the population aged 60 and over increased from 32% in 1973 to 79% in 1984 and to 91% in 2000.

This paper reports on the relationship between health insurance and longevity in a 17-year prospective panel study of about 900 Costa Rican adults aged 60 and above at the beginning of the observation. More specifically, it reports the difficulties of assessing the impact of health insurance because of self-selection of healthy individuals out of insurance cover, while poor-health individuals may tend to seek more actively insurance cover. It also analyses longevity levels in the sample and reports the prospective effects of socioeconomic conditions on survival.

Methods

A cohort of 876 individuals aged 60 and over, residents in the community of Coronado, Costa Rica, in 1984, were analysed. Coronado is a relatively homogeneous semi-urban community on the outskirts of the capital San José. It had approximately 25,000 inhabitants when the study started and 56,000 in the year 2000. In May 1988, physical access to health services dramatically improved in Coronado with the opening of a large integrated health centre offering medical services at the second level of complexity (laboratories, X-rays, specialized medicine, and the likes). People in Coronado show a health status slightly below the Costa Rican average, as measured by the infant mortality rate: 12 compared to 11 per thousand (source: http://censos.ccp.ucr.ac.cr).

The individuals in the study are 876 listed in the 1984 census in two districts of Coronado (San Isidro and Patalillo) aged 60 and over as reported in the census. This sample was originally drawn to study census age misreporting among elderly people (Ortega & García, 1986). The study had access to the information collected in the 1984 census questionnaire for these individuals and their households, which include data on gender, insurance, education, assets, marital status, co-residents, living children, among others. Individuals were further surveyed in June 1985, 12 months after the census. A second re-interview took place in October 1986. The numbers of individuals alive and residing in the area were, respectively, 802 and 753, in these two visits. A third contact was made by June 1988 to determine just survival status. The original research team that started the panel made these three contacts.

The original data collection efforts were complemented with a computer follow-up of the panel in the database of the voting system at the end of 2001. This database includes all Costa Ricans ever alive since the early 1970s. Using the name and birth date (which were established from the census and the two visits), for the individuals in the panel the unique identification number – the *cédula* – that all Costa Ricans have was determined. A computer algorithm developed by Mr Daniel Antich was used to order the most likely matches. With the identification numbers, these were searched for in the database of deaths of the National Registry until December 2001 to determine those who died and their death date. Those individuals alive in the voting registry – the *padrón* – for the presidential elections of 1990, 1994, 1998 and 2002 were also double-checked. Inconsistencies were resolved on a case-by-case basis. It was not possible to determine unequivocally the identification number of 88 individuals (some were foreigners). Many of them were, however, contacted in some of the visits.

Those individuals who were alive, according to the records, at the end of 2001 were interviewed by phone or in person in November 2002. A total of 250 living individuals were contacted, and there has been 31 deaths (most occurred in 2002). It was not possible to contact 22 individuals. In this way, at the end of the follow-up process, by December 2001, 589 deaths, 265 living individuals, and 22 losses to follow-up (censoring) with last contact on October 1986 were recorded.

This follow-up procedure, with its multiple checks, ensured that individuals recorded as 'alive in 2002' were certainly alive, since they were actually contacted. This means that estimated mortality rates in the panel cannot be down-biased. The estimates could be, however, up-biased in the unlikely event that some deaths were mistakenly identified.

The study uses standard procedures for survival analyses: Kaplan–Meier curves for descriptive comparisons and Cox proportional hazards regression models with (annual) time-varying covariates for multivariate analysis (Hosmer & Lemeshow, 1999). Life table techniques were also used to translate some of the results into life expectancy – an indicator of longevity.

The dependent variable is the death event, as well as time-until-death. Living individuals by December 2001 were considered censored observations at that date. As mentioned, there were also 22 individuals censored by October 1986.

Health insurance cover is the key explanatory variable in the analysis. The insurance status at the beginning of the observation period, i.e. in the 1984 census, was considered. Costa Rican censuses are unique in collecting information on health insurance cover, to determine participation in the national social security fund (CCSS), which is mandatory for formal sector employees. Three categories of insurance cover are defined in the analysis: (1) those who obtained this cover through current or former employment or as a dependant (spouse, child or parent) of those directly insured (employer insurance); (2) those who are covered by the government as indigents, or who voluntarily enrol in the system (voluntary insurance); and (3) those with no insurance cover. The second group is called 'voluntary insurance', because a volitional act is required to obtain cover, in contrast with the automatic and compulsory cover provided to wage-earners and their families. It is suspected that some individuals in the second group become insured only when falling sick, and thus miss the preventive benefits of long-term insurance cover and even can show poorer health status than the other groups.

The effects of other demographic and socioeconomic characteristics are also looked at, either to control their confounding effect on insurance or to determine their net effect on longevity, a worthy purpose by itself given how little is known about it in developing countries. These other variables are:

Age. At the mid-point of one-year observation segments. This is a time-varying covariate. It was computed with the information on the exact birth date in the National Register (it may differ from the census reported age).

Sex. As dummy variable with 1=male and 0=female.

Baseline mortality. A transformation of the variables age and sex, which are replaced in each individual with the corresponding death rate from a standard model of mortality for old ages proposed by Himes *et al.* (1994). In the regressions the natural logarithm of this rate is used and, consequently, the regression coefficient measures elasticity. This is a time-varying covariate.

Education. As reported in the 1984 census. Dummy variable with 1=completed elementary school and 0=less than completed elementary school.

Married. From the marital status question in the 1984 census, transformed into a dummy with 1=married or in a consensual union.

Wealth. Three categories: poor, middle and rich according to the number of assets in the household, as reported in the 1984 census. Thirteen assets were considered: running water, electricity, bathroom, no-dirt floor, house owner, TV, refrigerator, washing machine, hot water, telephone, electric broom, and car.

Autonomy. Dummy variable with 1=fully autonomous individual: can eat, dress, comb, walk, stand up, take a bath, and cut toenails with no help. These seven activities were asked in the second re-survey in 1986 of 753 individuals (123 missing data).

Results

The 876 individuals in the study rendered more than 10,000 observation years (Table 1). More than half were covered by employer insurance in 1984, 22% had no insurance, and a similar percentage were insured by the government or were volunteers (voluntary insurance). Although at the beginning of the study, more than half were aged below 70 years, only 22% of the observation corresponds to these ages, while 48% corresponds to the ages 70–79. Only 427 (4%) observation years are in ages 90 and more. Given that preliminary analyses showed interaction between the effects of sex and marital status on mortality, these two variables were combined. The smallest group is that of not married men (11%) and the largest is that of married men (34%). More than a quarter of the study group had completed elementary school, and a similar number were classified either in the 'rich' or the 'poor' wealth categories. One-quarter is also the proportion of individuals who were not fully autonomous in the 1986 interview.

Figure 1 shows that age-specific death rates in the panel do not differ significantly from those of Costa Rica (1985–2000, internet source: http://censos.ccp.ucr.ac.cr) and the United States (1990–95, internet source: 'Human Mortality Database' at http://www.mortality.org). The age pattern of mortality in the panel approximately parallels that of the model proposed by Himes *et al.* (1994) although the mortality level is significantly lower in the panel. The Himes model can thus be used as a baseline or standard for modelling mortality in this population. Life expectancy at age 60 summarizes these mortality curves. Costa Rica has a one year longer life expectancy than the US (21·8 compared with 20·8 years). Although the panel had a slightly shorter life expectancy (20·4 years), in a way this confirmed the outstanding longevity of the Costa Rican population.

Figure 2 shows the Kaplan–Meier survival curves by selected variables. All these curves show effects controlled by age at the first interview (which is equivalent to controlling for birth year). (The Stata software (StataCorp, 2001) controls for, in this case, age effects by scaling the curves to the average of age across all the groups in the figure. To do that, Stata first estimates age effects using Cox regression.) Parts A and B of the figure show that socioeconomic effects on survival tend to be weak in this population. Although adults who completed elementary school had a higher

Table 1. Distribution of the sample by selected characteristics

Characteristics	% sample	% years	*N* (person years)
Total	100	100	10,173
Insurance			
None	22	22	2299
Employer	55	58	5890
Voluntary	22	20	1984
Age			
60–69	54	22	2274
70–79	33	48	4916
80–89	11	25	2556
90 +	2	4	427
Sex & marriage			
Lone male	13	11	1082
Lone female	32	31	3116
Married male	34	34	3481
Married female	22	25	2494
Elementary school			
Not completed	74	71	7259
Completed	26	29	2914
Wealth			
Poor	28	26	2616
Middle	44	45	4594
Rich	28	29	2924
Autonomy			
Non-autonomous	32	26	2516
Fully autonomous	68	74	7108

survival curve, the effect is marginally significant ($p=0{\cdot}06$ for a difference of 1·3 years in the median survival time). The wealth indicator does not show a trend or gradient effect. Middle-wealth individuals show higher survival than the poor, most of the time. Survival of rich individuals, however, is below that of middle-wealth and similar to the poor individuals.

The variables sex and marriage interact in their effect on survival (Fig. 2C). Males have lower chances of survival, but this disadvantage mostly comes from the substantially lower survival curve of men who were unmarried at the beginning of the observation. Married men show only a slightly lower survival curve than married women. Among women, marital status does not make difference.

Along with lone men, not fully autonomous individuals show the lowest survival curve in this panel (Fig. 2D). Note that in the first two years there is no difference given that the information to build this variable was collected two years after the panel began. The lack of autonomy is probably an indicator of poor health and thus a predictor of short life expectancy.

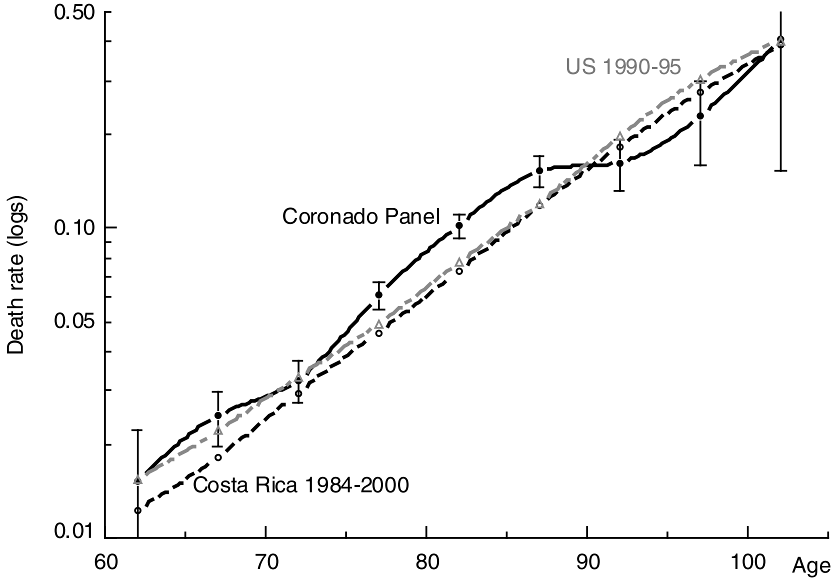

Fig. 1. Age-specific mortality rates in the panel and in two populations.

The Kaplan–Meier curves for the three categories of health insurance cover show cumbersome patterns (Fig. 2E). Voluntary-insured individuals (funded by themselves or by the government as destitute) tend to be the ones with lowest survival, supporting the hypothesis that there is a self-selection effect; i.e. that individuals in poor health and with no insurance cover tend to move into the voluntary insurance category. Individuals with no insurance in 1984 show a low survival curve, similar to the voluntary insurance group, but only in the earlier years of the observation. By year 8 the curve of the uninsured crosses over the curve of the employer-insured and becomes the highest survival curve. The median life span in the figure is 11 years for the uninsured, 10 years for the employer insurance group, and 8·5 years for the voluntary insurance category.

The survival function is essentially the same for the three categories of health insurance cover within the group lacking full autonomy (figure not shown). In contrast, within the group of fully autonomous (and thus healthy) individuals, the voluntary-insured show a clearly lower survival function starting in year 5 (Fig. 2F). In turn, the uninsured survival is similar to that of the employer-insured until about year 8 of observation. After this point in time, the uninsured present the highest survival curve. The only conjectural explanation for this behaviour is a natural selection process of the fittest that operates only among the uninsured. It was not possible to connect this behaviour with the opening of the Coronado Health Center in year 4, which improved substantially access to health care for all individuals in the community, independent of their insurance status.

Table 2 summarizes the results of the discrete time hazard regressions, which simultaneously control the effects of all variables in the models. Having voluntary insurance cover is associated with prospective death hazards that are, on the average,

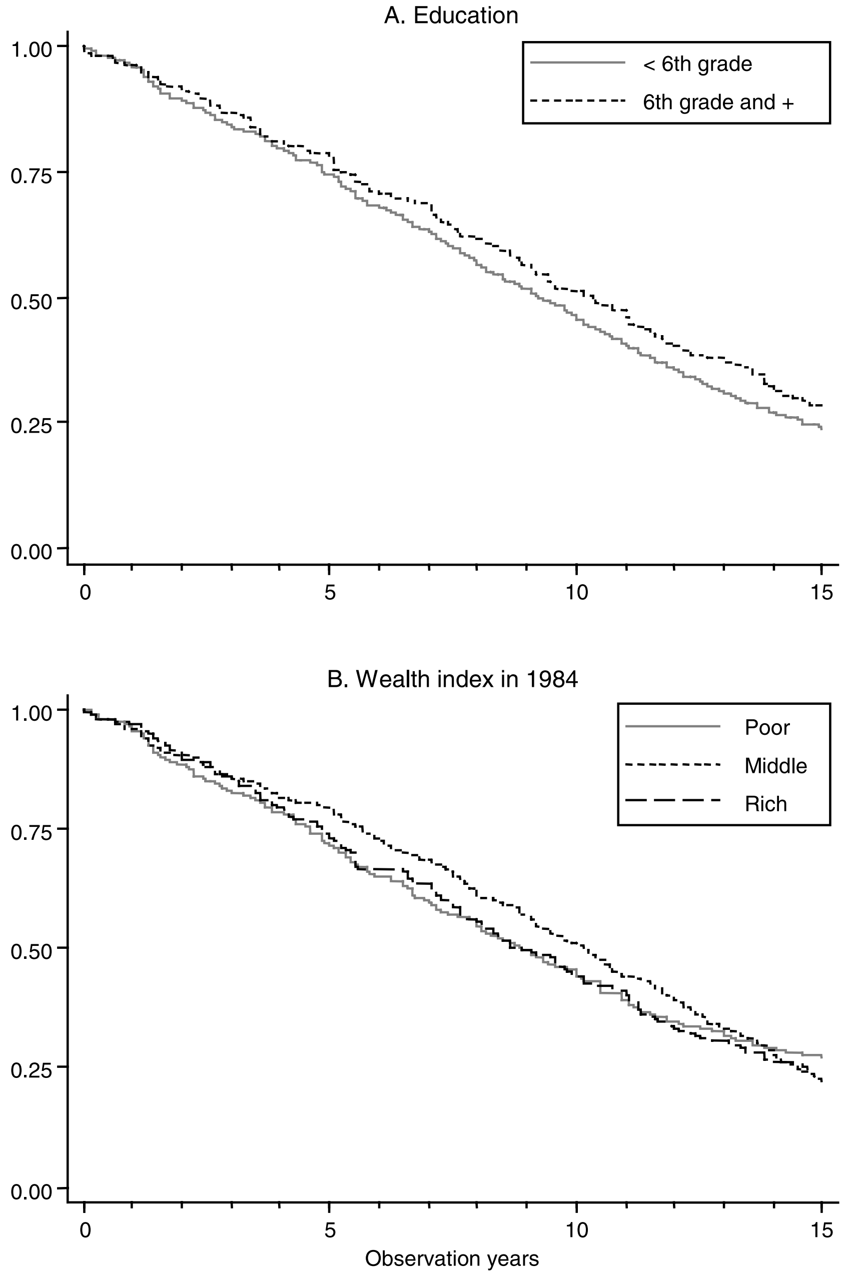

Fig. 2. Kaplan–Meier survival functions adjusted for age in 1984.

20% higher than the employer insurance group. This effect is marginally significant and it is stronger during the first few years of observation. Having no insurance cover is significantly associated with 28% lower death hazards compared with employer

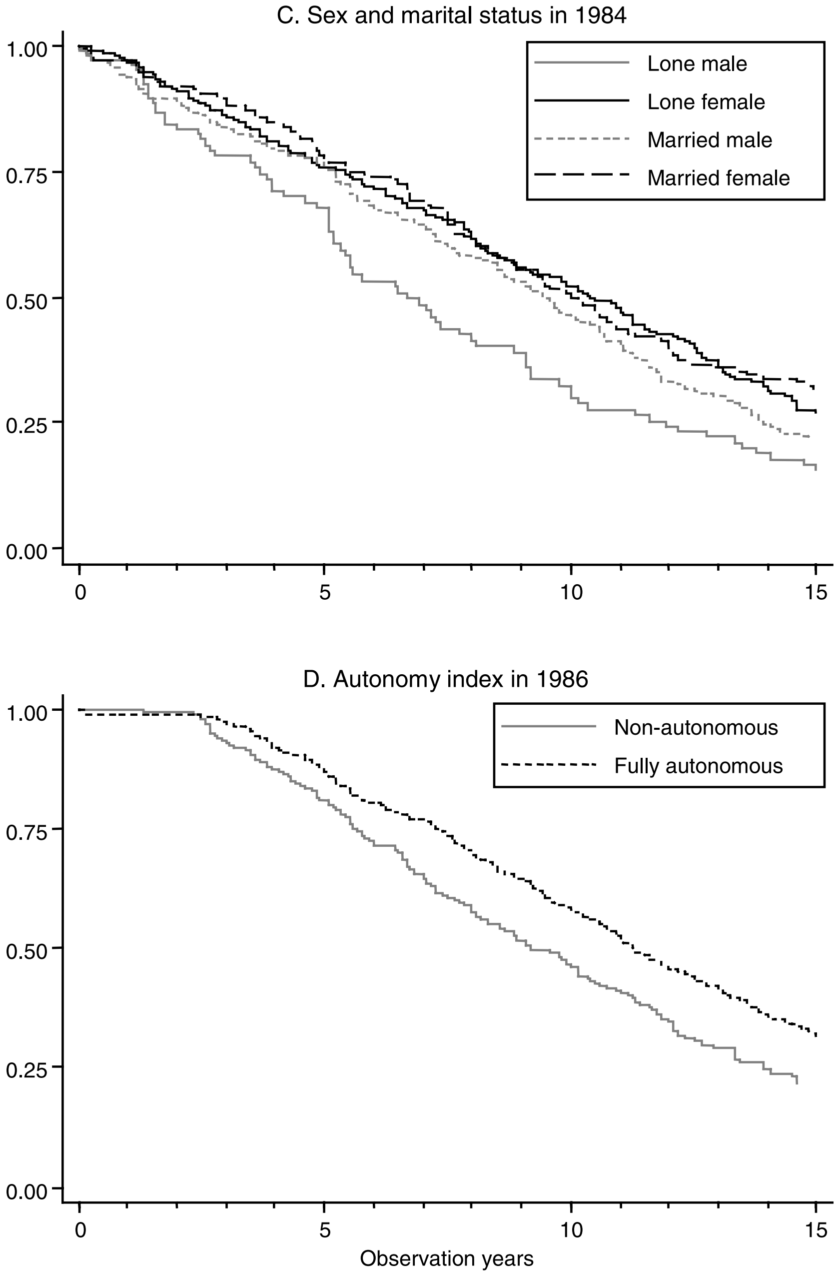

Fig. 2. Kaplan–Meier survival functions adjusted for age in 1984.

insurance and 39% lower compared with voluntary insurance. This association emerges only after several years of observation. In the earlier observation period the uninsured show higher death hazards than the employer insurance group, but there

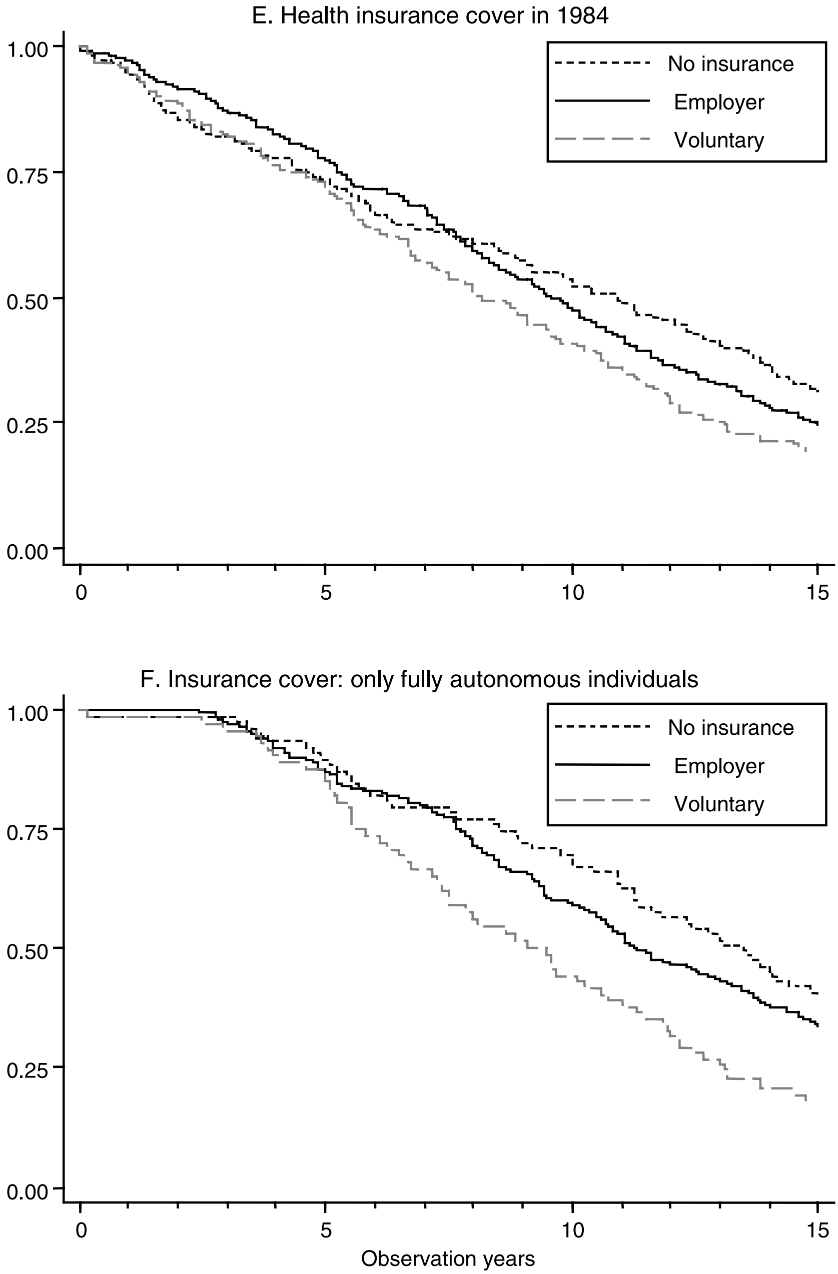

Fig. 2. Kaplan–Meier survival functions adjusted for age in 1984.

was not enough statistical power for this effect to be significant. Controlling for the variable autonomy (which also requires discarding the two first years of observation) produces results that are similar to those in the model for 1989–2001. No significant

Table 2. Death hazard ratios from multivariate Cox regression models

Explanatory variables	Model 1 1984–2001	Model 1 1984–1988	Model 1 1988–2001	Model 2 1986–2001
(*N* person years)	(10,133)	(3961)	(6172)	(7344)
Insurance cover				
None	0·84*	1·19	0·72**	0·77**
Employer	1·00	1·00	1·00	1·00
Voluntary	1·20*	1·32*	1·17	1·15
Sex & marriage				
Lone male	1·34**	1·26	1·42**	1·32**
Other	1·00	1·00	1·00	1·00
Elementary school				
Not completed	1·00	1·00	1·00	1·00
Completed	0·82**	0·79	0·83*	0·84*
Wealth				
Poor	0·99	1·29*	0·87	0·97
Middle	1·00	1·00	1·00	1·00
Rich	1·05	1·35*	0·95	1·06
Autonomy				
Non-autonomous				1·00
Fully autonomous				0·71**
Baseline mortality elasticity	0·85**	0·72**	0·96**	0·90**

**Significant at $p<0{\cdot}05$; *marginally significant at $p<0{\cdot}15$.

statistical interaction effects was found between insurance and the other variables, including autonomy (results not shown).

The regression models include age- and sex-specific death rates of a baseline mortality model (a logarithmic transformation). The elasticity of the baseline rates is slightly below 1·0, which means that the Costa Rican mortality pattern with age and sex (male) does not increase as fast as in the baseline model.

Unmarried men in this panel present prospective death hazards that are 30% to 40% higher than the rest of the population. And this effect is above and beyond the expected sex and age effects, which are controlled with the baseline mortality rates. Individuals who reported need of assistance to perform any of seven daily life activities are also about 40% (1·0/0·71=1·41) more likely to die each year than fully autonomous adults.

Of the two socioeconomic variables included in the models, only education shows a consistent association with the death hazards. Individuals with completed elementary school (one-quarter in this sample) have about 20% lower death hazards than the individuals who did not complete it. This effect is independent of wealth, insurance cover, age, sex, and even the indicator of initial health status (autonomy). The effects of wealth are not statistically significant.

Discussion

This article reports a prospective survival analysis in a panel of 876 Costa Ricans aged 60 and over at the beginning of the study. Such data sets are extremely rare for developing country adults, thus this is one of the first studies of its kind to document micro-level survival correlates from a prospective sample of adults in a developing country. The long 17-year follow-up period further adds to the uniqueness of the study. However, a limitation of this data set was the limited information available for each individual. There are many more factors hypothesized to impact survival in old age than those available for this analysis. For example, it was not possible to analyse diet, exercise, stress, early life conditions, or length of time in the insurance and marital categories. In addition, there was no valid information on causes of death, thus it was not possible to make inferences on quality of life or specific health conditions.

The sample is the complete 1984 age 60+ population of Coronado, a semi-urban community in the outskirts of Costa Rica's capital city of San José. The observation period began in June 1984 with the census visit and ended in December 2001. It included four household visits as well as computerized tracking in the death and voting registers. Attrition was extremely low, with less than 3% of the panel unaccounted for at the end of the study.

The small sample size of the panel, especially for studying survival, is compensated by the long follow-up period. In contrast to other studies in larger samples that often track mortality for short periods, during which only a small portion of the sample dies and the vast majority of deaths are censored, this study followed individuals for 17 years, allowing the observation of deaths among 69% of the sample. Furthermore, over these 17 years more than 10,000 person-years were observed for the analysis.

Age-60 life expectancy in the panel was 20·4 years, or 1·4 years shorter than vital statistics estimates for the entire Costa Rican population. Most remarkably, this sample's age-60 life expectancy was only 0·4 years shorter than in the US population. This result confirms the outstanding longevity of Costa Rican adults compared with adults in more developed societies with a health service supply environment many times richer and more sophisticated. Why is it so? These data suggest that even poor and low-educated Costa Ricans are not particularly disadvantaged in survival. Economic development, wealth, and even education, do not seem to explain the health achievements of this country.

One commonly held hypothesis is that Costa Rica's high adult survival may be caused by its universal health insurance. This paper has attempted to test this hypothesis, but this has been complicated by strong evidence of adverse selection that leaves healthier individuals in the group with no insurance cover. By distinguishing two subcategories of health insurance cover, it was possible to show that those who were automatically covered because of their employment had higher survival than those who *chose* to get insurance cover. Given that some of the uninsured are in that category by choice (probably because they are healthier), their counter-intuitive higher survival makes some sense. These selection problems prohibit assessment of the effect of health insurance cover in this panel. If beneficial effects of insurance had been found despite this adverse selection then this arguably could have been considered a lower bound, implying that insurance did have positive effects. Given that in fact unexpected negative relationships were found between insurance and survival, however, it was not possible to draw any firm conclusions supporting or rejecting the insurance hypothesis.

An alternative approach would have been to compare those with mandatory health insurance of employees in the formal sector against all the other individuals, i.e. those with no insurance or with voluntary insurance. The problem with this approach is that any true insurance effect would have benefited the group with voluntary insurance, increasing its survival and thus masking part of the true insurance effect. In such comparison, a beneficial effect of insurance should also be taken as a lower bound, and a lack of observed effect should not mean that there is no insurance effect. As a matter of fact, the Kaplan–Meier curves for these two insurance groups (figure not shown) showed that those with mandatory insurance had slightly higher survival in years 2 to 8 of observation. The two survival curves were identical in the other years. Accordingly, a regression model similar to that in the second column of Table 2 resulted in death hazards 21% lower for those with mandatory insurance in 1984–1988, but this effect was not statistically significant ($|p>Z|$ was 0·13). In the other three models the effects of mandatory insurance were nil and, of course, non-significant.

Beyond insurance, a number of other relationships in the data are also of interest. One of the strongest associations in these data is that unmarried men appear to be at considerable survival disadvantage in this panel. There are well known difficulties for sorting out selection from protection effects in the relationship between marriage and survival. One of the suggested remedies for isolating causal relationships is having longitudinal, prospective studies (Goldman, 1993, p. 191). Although this design cannot fully rule out selection, the prospective data thus provide important new evidence that there may be a true protective effect of marriage for men. The evidence is stronger since this effect persists after controlling the initial health status as measured by the indicator of autonomy.

These findings indicate in particular a synergistic negative effect of being a man and unmarried. Among women in the sample there are no survival benefits associated with marriage; among married individuals, the gender effect on survival is minimal, if any. There is ample evidence from developed countries of the survival benefits of marriage, especially among men (Hu & Goldman, 1990), but little is known about developing countries. The exception is Bangladesh, where the demographic surveillance system of Matlab has documented that the single most important determinant of mortality at old ages is marital status (Mostafa & van Ginneken, 2000). Having a spouse significantly reduces mortality in both elderly men and women (Rahman, 2000). The current study's results indicate that the Bangladesh relationships do not generalize to all other low-income countries. It may be that the status of women makes them more vulnerable outside of marriage in south Asia than in other regions such as Latin America.

The Costa Rican panel also showed that more educated individuals have higher survival opportunities, whereas household wealth has little relationship with longevity in this population. This negative wealth finding is consistent with prior studies in countries that have run into no, or perverse, effects of economic development on mortality in adults (not so in children) (Rosero-Bixby, 1995). It is also consistent with the observation that adult longevity in Costa Rica is comparable to that of substantially wealthier societies such as the US, implying that wealth is not the key protective factor in Costa Rica.

A shortcoming of this analysis is that the variables insurance cover, wealth and marital status were taken frozen in time at the values observed at the beginning of the study. Data on changes occurring in these variables were simply not available. However, a question asked of 240 surviving individuals contacted in 2002 shows that only 3% of those with insurance cover lost it after 17 years, while 65% of those with no insurance in 1984 had gained cover in 2002. There was no information on insurance changes for those who had died prior to 2002 and consequently they could not be included in the survival analyses. Similarly, there was no information on insurance history prior to 1984, thus no attempt was made to make inferences about effects of given lengths of uninsurance exposure. In any case, to study the prospective predictive value of characteristics measured at the beginning of the follow-up is a valid research strategy.

Given the large public finance implications of insurance expansions, it is imperative to understand the health benefits of investing in insurance programmes. The mortality cross-over among insured and uninsured individuals in this sample suggests that insurance research in observational samples must be undertaken with great care. Insurance status is chosen by individuals, and this selection process is likely to depend on a complex mixture of short-term health shocks and long-term frailty. Future research into this selection process in different settings will be important for helping to interpret the growing literature on the relationship between insurance and health outcomes.

There are many other additional hypotheses for future research to test regarding why Costa Rica's adult longevity compares so favourably with richer countries. One hypothesis is that this reflects a 'survival of the fittest' process in which only the genetically strongest individuals fight off early childhood threats, and that Costa Rica's surviving adults are genetically better able to withstand adult mortality threats than are average surviving adults in rich countries. This hypothesis, though, would imply that adult mortality rates in Costa Rica should be relatively less favourable for more recent cohorts that experienced much lower child mortality. In fact, analyses of adult age-specific mortality rates over time reveal that Costa Rican adult age-specific mortality rates became lower than in the United States starting in 1960, and that this trend has not since reversed for more recent cohorts (Rosero-Bixby, 1995). Thus selection is unlikely to be the primary explanation.

A more policy-relevant health care related hypothesis emphasizes the excellent access to primary health care in Costa Rica, even independent of insurance. This could have helped Costa Rica reduce certain medically preventable causes of death, and is consistent with the fact that infectious causes have been reduced to only a small portion of elderly deaths in Costa Rica. But it is unclear whether Costa Rican primary health care is actually superior to that of richer countries, and in particular superior enough to offset the paucity of high technology medicine. A different health care related hypothesis is that in fact much of the high technology medicine used in richer countries has little survival benefit, and that Costa Rica has appropriated only the most cost-effective life-extending technology. It is possible that a large portion of the health care spending differential can be accounted for by health care that is palliative, only affects morbidity, or else is wasted on futile efforts that have minimal life-extending benefits. Testing of this hypothesis, however, will require detailed health care utilization comparisons, and such data are not available in the current study.

An alternative set of hypotheses relate to social and behavioural determinants of health. It may be that whatever mortality benefit is conferred by rich countries' superior health systems is offset by worse risk factors. Previous research has indicated that Costa Rica has particularly low cardiovascular mortality compared with the United States (Rosero-Bixby, 1995). Do Costa Ricans have less stress, more physical activity, better nutrition, and hence less obesity, hypertension, etc. than developed country elderly? These are all intriguing hypotheses about which little is known in the Costa Rica context. The authors are currently beginning a new Costa Rica Healthy Aging Survey that will in several years allow further testing of these and other hypotheses.

Acknowledgments

The panel of individuals in this study was originally created by the Centro Latinoamericano de Demografía (CELADE), Dirección General de Estadística y Censos (currently INEC) and the Instituto de Investigaciones en Salud (INISA) of the Universidad de Costa Rica, with support of IDRC-Canada. This analysis was conducted with the support of grants from NICHD (R01 HD38330) and the Bill and Melinda Gates Foundation.

References

Brook, R. H. *et al.* (1984) Does free care improve adults' health? Results from a randomized controlled trial. *New England Journal of Medicine* **309**, 1426–1434.

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

Currie, J. & Gruber, J. (1996) Health insurance eligibility, utilization of medical care, and child health. *Quarterly Journal of Economics* **111**(2), 431.

Currie, J., Gruber, J. & Fischer, M. (1995) Physician payments and infant mortality: evidence from Medicaid fee policy. *American Economic Review* **85**(2), 106.

Dow, W., Gonzalez, K. & Rosero-Bixby, L. (2003) *Aggregation and Insurance-Mortality Estimation.* National Bureau of Economic Research (NBER) Working Paper #9827, Cambridge, MA.

Dow, W. & Schmeer, K. (2003) Health insurance and child mortality in Costa Rica. *Social Science and Medicine* **57**(6), 975–986.

Gertler, P. & van der Gaag, J. (1990) *The Willingness to Pay for Medical Care*. Johns Hopkins University Press, Baltimore.

Goldman, N. (1993) Marriage selection and mortality patterns: inferences and fallacies. *Demography* **30**(2), 189–208.

Himes, C., Preston, S. & Condran, G. (1994) A relational model of mortality at older ages in low mortality countries. *Population Studies* **48**(2), 269–291.

Hosmer, D. W. & Lemeshow, S. (1999) *Applied Survival Analysis*. John Wiley & Sons, New York.

Hu, Y. & Goldman, N. (1990) Mortality differentials by marital status: an international comparison. *Demography* **27**(2), 233–250.

Levy, H. & Meltzer, D. (2001) *What do we Really Know about Whether Health Insurance Affects Health*? Working Paper 6, Economic Research Initiative on the Uninsured, University of Michigan.

Manning, W. G., Newhouse, J. P., Duan, N., Keeler, E. B. & Leibowitz A. (1987) Health insurance and the demand for medical care: evidence from a randomized experiment. *American Economic Review* **77**, 251–277.

Mesa-Lago, C. (1985) Health care in Costa Rica: boom and crisis. *Social Science and Medicine* **21**, 13–21.

Mostafa, G. & van Ginneken, J. K. (2000) Trends in and determinants of mortality in the elderly population of Matlab, Bangladesh. *Social Science and Medicine* **50**(6), 763–771.

Ortega, A. & García, V. (1986) *Estudio Experimental sobre la Mortalidad y Algunas Caracteristicas Socioeconomicas de las Personas de la Tercera Edad*. CELADE Organization, Series A, No. 1049. Centro Latinoamericano de Demografia CELADE, San Jose, Costa Rica.

Pan American Health Organization (2002) *Country Statistical Reports*. Pan American Health Organization, Washington, DC.

Population Reference Bureau (2002) *2002 World Population Data Sheet*. Population Reference Bureau, Washington, DC.

Rahman, M. O. (2000) The impact of co-resident spouses and sons on elderly mortality in rural Bangladesh. *Journal of Biosocial Science* **32**(1), 89–98.

Rosero-Bixby, L. (1995) The decline in adult mortality in Costa Rica. In Chackiel, J., Ruzicka, L. & Timaeus, I. (eds) *Adult Mortality in Latin America*. Oxford University Press, pp. 166–198.

Rosero-Bixby, L. (2002) *Tendencias en la Mortalidad y Esperanza de Vida. Costa Rica 1970–2001*. Proyecto Estado de la Nación, San José, Costa Rica.

Rosero-Bixby, L., Brenes, G. & Collado, A. (2004) Tablas de vida para cálculo actuarial de rentas vitalicias y retiro programado. Costa Rica circa 2000. *Población y Salud en Mesoamérica. Revista Electrónica*, vol. 1(2), art. 4. http://ccp.ucr.ac.cr/revista/inicio.htm

StataCorp (2001) *Stata Statistical Software: Release 7·0*. Stata Corporation, College Station, TX.