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ORIGINAL INVESTIGATION

# Self-rated health and mortality risk in relation to gender and education: a time-dependent covariate analysis

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**Abstract** This study examines the relations between self-rated health (SRH) at baseline, SRH as a time-dependent covariate (TDC), and mortality by gender and education in a community-dwelling older population in Spain. The data used are from the longitudinal study "Aging in Leganes", launched in 1993, carried out in a community-dwelling representative sample ($n = 1{,}560$) of the older population of Leganes (Spain). Mortality was assessed in 2008. Proportional regression models were fitted to examine the association between mortality and baseline SRH, and SRH as a TDC among subjects aged 65–85 at baseline. The multivariate analyses were stratified by gender and education and adjusted for sociodemographic factors, smoking and physical activity, physical and mental morbidity, and ADL disability. SRH and SRH as a TDC were significant predictors of mortality in men and in people with some education, but not in women or in illiterate persons. SRH and declines in SRH were associated with increased mortality risk in older men and in those who can read and write in this Mediterranean population. Given current improvements in education and decreasing gender inequality, health professionals in Spain should pay attention to both current SRH and declines in SRH in their patients regardless of gender and literacy.

**Keywords** Self-rated health · Time-dependent covariate · Mortality · Cohort analysis · Older persons

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## Introduction

A number of authors have raised questions about the cross-cultural validity of self-rated health (SRH). Sen (2002) affirmed that self-reported morbidity can be misleading, since the patient's internal assessment may be influenced by his/her own social experiences. He gives the example of India, where the low self-rated morbidity is related to lower life expectancy in inter-state comparisons. Contrary to Sen, Subramanian states that SRH is a valid measure of health in India (Subramanian et al. 2009). The debate for and against the validity of SRH as a measure of true health has not been resolved, as demonstrated by recent conceptual discussions in several articles (Quesnel-Vallee 2007; Jylha 2009; Huisman and Deeg 2010).

In studies in high income countries, SRH has been established as a predictor of mortality (Idler and Benyamini 1997; Benyamini and Idler 1999; DeSalvo et al. 2006). These systematic reviews and meta-analysis have estimated that, on average, those reporting poor health have double the mortality risk compared with those in good health.

Several studies have found gender differences (McCallum et al. 1994; Jylha et al. 1998; Helmer et al. 1999; Deeg and Kriegsman 2003), but the results are contradictory. Also,

socioeconomic variations in the associations between SRH and mortality are not consistent (Burstrom and Fredlund 2001; van Doorslaer and Gerdtham 2003; Dowd and Zajacova 2007; Singh-Manoux et al. 2007; Huisman et al. 2007; Regidor et al. 2010). Results from most, but not all, studies suggest that the validity of SRH as a predictor of mortality may be higher among those with high socioeconomic position. Some authors, using arguments similar to those offered by Sen (2002), argue that discrepant research results may be due to cultural, societal or socioeconomic differences across populations. In addition, strategies for modeling the associations between SRH and mortality have varied with regard to confounding adjustment and the choice of models (Deeg and Kriegsman 2003). In some studies SRH is presented as a dichotomous variable while others have used it as a multiple response variable. In this latter set of studies, a gradient of increasing mortality risk with decreasing levels of health has been reported (DeSalvo et al. 2006). In some of these studies, the predictive value of SRH for mortality remained after extensive controlling for socio-demographic characteristics, co-morbidity, depression, functional status, and cognitive function (Hays et al. 1996; Helmer et al. 1999; Nybo et al. 2003).

The evidence supports the dynamic nature of self-assessments of health, since individuals modify their assessments according to the changing nature of their health. In their 1999 study, Strawbridge and Wallhagen (1999) stated that people incorporate health status changes into their health ratings. Two years later, using data from a US sample of people over 21 years of age followed for 20 years, Ferraro and Kelley-Moore (2001) showed that self-ratings of health are sensitive to health declines and that ratings adjustments are associated with mortality risk. A pioneer study conducted in Swedish men born in 1913 found that SRH treated as a time-dependent covariate (TDC) was predictive of mortality at 8 years' follow-up (Svardsudd and Tibblin 1990). Since then, a few research papers have shown that models of SRH treated as a TDC have stronger predictive values than models using only baseline SRH values. These studies have used similar statistical methods analyzing SRH as a TDC in Cox regression models (Strawbridge and Wallhagen 1999; Ferraro and Kelley-Moore 2001; Han et al. 2005; Lyyra et al. 2009), but they vary in the age range of the populations studied, restriction to women or men and location of study. Strawbrige and Wallhagen (1999) reported that SRH–TDC was predictive of mortality in women and men, in older and young adults, and in white and black people from Alameda County. Ferraro and Kelley-Moore (2001) reported that SRH–TDC was predictive of mortality among black and white adults from 25 to 74 years old at baseline. Han et al. (2005) found that decline over time in SRH was a strong predictor of mortality among disabled older women (65 years or older) in a 3-year follow-up. In a follow-up of 5 and 10 years, Lyyra et al. (2009) found that change over time in SRH was predictive of mortality in women, after controlling for a number of chronic diseases, in a population of persons aged 75 years and over.

Most studies of the predictive values of SRH and all studies of the predictive value of SRH–TDC on mortality have been conducted in populations with relatively high levels of education and with similar distributions of SRH in men and women. However, international comparisons reveal gender and education differences in the distribution of SRH. For instance, in Canada and Northern Europe no gender differences have been observed in the distribution of SRH (McDonough and Walters 2001; Zunzunegui et al. 2004), whereas women have consistently reported worse health than men in populations from Italy, Israel, and Spain (Bardage et al. 2005), Latin America and the Caribbean (Zunzunegui et al. 2008). In European countries, gender differences in the distribution of SRH have been reported in the late democracies but not in older democracies (Espelt et al. 2008). It has also been observed that educational differences in SRH are smaller in social democratic countries compared with other political traditions (Borrell et al. 2009).

Older people in Spain share their high longevity with other Mediterranean populations. In 2002, life expectancy after age 65 was 21 years in women and 17 years in men (Ministerio de Sanidad y Consumo 2006, April). However, these generations of older Spanish people were raised in a highly stratified society with little opportunities for education and with marked gender roles as indicated by fewer educational and occupational opportunities for women.

The longitudinal study "Aging in Leganes" conducted from 1993 to 2006 provides an opportunity to test the hypothesis that SRH at baseline and SRH as a TDC are predictive of mortality in a Mediterranean older population with low levels of formal education and with marked gender differences in the distribution of SRH. The main objective of this work is to describe the associations between SRH at baseline, SRH as a TDC and mortality risk by gender and education in a Mediterranean older population followed during 15 years.

## Methods

### Study population

We used data from "Aging in Leganes" (Zunzunegui et al. 2001), a longitudinal study (1993–2008) with 15 years of follow up. "Aging in Leganes" was initiated in 1993 with an age- and sex-stratified random sample ($n = 1{,}560$) of

the population aged 65 years or older (range 65–101) living in Leganes, a suburban municipality located 8 km outside Madrid. Follow-ups were later carried out in 1995, 1997, 1999, and 2006. In 1993, 1,283 individuals completed the survey (82% baseline response rate); in 1995, 1,007 participants; in 1997, 869; in 1999, 519; and in 2006, 286.

All persons between 65 and 85 years of age at baseline and who answered the question on SRH at baseline were included in the analysis ($n = 1{,}016$). For the assessment of the association between SRH as a TDC and mortality, we used the first three data collection periods (1993, 1995, and 1997).

### Mortality

Deaths were ascertained by computer linkage to the National Death Registry, upon authorization of the Ministry of Health, and using the first name as well as the two last names as is customary in Spain. The cumulative number of deaths over the 15-year period was 1,055 out of the total sample of 1,560 subjects. In the present study the number of deaths was 615 of the 1,016 individuals (263 women and 352 men).

### Measures

SRH was assessed by the question: "At the moment, how would you describe your health status: very good, good, fair, poor or very poor?" For the main objective, categories 1 and 2 ("very good" and "good") were combined as "good" and categories 4 and 5 ("poor" and "very poor") as "poor". For other statistical analyses, "very good/good" and "fair" were combined as "good" and this was compared with "poor/very poor".

### Potential confounders

The socio-demographic factors included age (as a continuous variable), gender, marital status ("married" vs. "other"), and education ("illiterate" (unable to read and write), "incomplete primary" (no schooling but can read and write) and "complete primary"). In our Leganes study, the effect of illiteracy on all health and functional outcomes is strong. This effect is stronger than the education gradient among those who have been able to learn how to read and write. For this reason, "incomplete primary" and "complete primary" were combined as "some education" in the multivariate analysis.

Morbidity was assessed by the number of chronic conditions, cognitive function, and depressive symptoms. Chronic conditions were measured by asking the older person if he/she had been diagnosed by a doctor, using a list of seven chronic problems (hypertension, heart disease, circulation problems, stroke, diabetes, chronic respiratory problems, and arthritis). Cognitive function was ascertained with the *Prueba Cognitiva de Leganes* (PCL), a test developed to screen for dementia in populations with low levels of education. The PCL, with scores ranging from 0 to 32, has been validated to screen for dementia with a sensitivity of 93% and a specificity of 94% at the 22/23 cut-off point (De Yebenes et al. 2003). For descriptive purposes, the cognitive score was dichotomized at the cut-off for dementia (22 or less) but used as a continuous variable in the survival analysis. Depressive symptomatology was measured with the 20-item Centre for Epidemiologic Studies Depression (CES-D) questionnaire from the Hispanic Health and Nutrition Examination Survey (Moscicki et al. 1989). For the descriptive analysis, the recommended 16-point cut-off was used. Disability in the activities of daily living (ADL) was assessed by asking individuals if they were able to carry out 8 ADL alone, with help, or not at all (walking around a small room, bathing or showering, grooming, dressing, eating, getting out of bed, getting out of a chair, and using the toilet). Based on this information, a three-category variable was created: "able", if the person was able to carry out all activities without help; "able with help"; and "unable" in at least one activity.

The health behaviors considered were smoking and physical activity. Smoking was categorized as "never smoked", "ex-smoker", or "currently smoking". Physical activity was assessed by the following question: How would you rate your level of physical activity? "light" (mostly at home, sitting or walking in the house), "moderate" (housework and walks outside of the house), and "vigorous" (practicing a sport or carrying heavy loads). This was coded as a dichotomous variable to distinguish those reporting light or no exercise from those reporting moderate or vigorous exercise.

### Statistical analysis

First, we fitted Cox proportional hazards models using baseline SRH as the main predictor. Second, we estimated hazard ratios for SRH as a TDC to incorporate more than one time point.

SRH as a TDC was created in three different ways, as recommended by Ferraro and Kelley-Moore (2001): (1) Using the most recent value available. If no change was reported, baseline information was used. If change was reported, the value reported at the most recent observation was used. (2) Using the most recent value but incorporating the timing of the transition in the model. This timing is taking into account by the inclusion of a dummy variable which takes the value of 1 at the time when the most recent value of SRH has been observed. (3) A third type of TDC

analysis incorporates in the model: the covariate at baseline (at 1993), change in the covariate and time of observation. The change in the covariate was measured as the difference between the covariate value at the most recent observation and the covariate at baseline. Time of observation was defined as the difference between the interview date at the most recent observation (date at 1997, 1995, or 1993) and the interview date at baseline (date at 1993); it takes a value of 0 if data were available only at 1993, and it takes values between 1.5 and 4.5 according to the latest interview date.

Because the estimate of −2 log likelihood function was best for the third analysis, only those results are presented in this paper. Additional results are available upon request.

Gender and education stratified analyses were carried out. Two sequential models were used to assess the relationship between SRH (baseline and TDC) and mortality. First, adjustments were made for age, gender or education, and marital status (Model 1). Second, adjustments were made for Model 1 plus number of chronic conditions and ADL disability as TDCs, and cognitive, depressive symptoms, and health behaviors at baseline (Model 2). Comorbidity and ADL disability were treated as TDCs to eliminate the possible influence of these on SRH–TDC estimates. Health behaviors and mental health were not included as TDCs because, in general, including more TDCs in the model would reduce our effective sample size. And, in particular, missing values for cognitive function scores, smoking and physical activities were more frequent because information on these variables was elicited in the second home visit during 1993 and 1995. Depressive symptoms were measured in the first home visit, but there were missing values in around 12–15% of the sample at each time.

The proportional hazards assumption was assessed by regressing the scaled Shoenfeld residual against the log of time and testing for zero slope (Hosmer et al. 2007). We estimated hazard ratios and 95% confidence intervals (CIs) for each category of SRH relative to "good".

## Results

### Baseline characteristics

Table 1 shows the distribution of covariates of the baseline sample. Compared with men, women had significantly lower education: one out of five women was illiterate versus one out of ten men. With regard to health behavior, women rarely smoked and reported less physical activity compared with men.

With respect to education, illiterate individuals had more comorbidity and disability than those with some education. At baseline, a larger proportion of illiterate subjects were depressed, and they had more cognitive impairment.

### Distribution of SRH in 1993, 1995, and 1997

The distribution of SRH measured in men and women in 1993, 1995, and 1997 is presented in Table 2. SRH was significantly associated with gender at each of the first three waves ($p \leq 0.001$). For SRH at baseline, 113 women (22.5%) rated their health as poor compared with 60 men (11.7%).

In 1995, individuals included in the analysis did not differ either in age or gender when compared with excluded subjects ($p > 0.05$). Men were more likely to die during follow-up, while women were more likely to be lost to follow-up in our cohort, probably due to moving out of Leganes and into children's or relatives' homes as a consequence of deteriorating health. In 1997, the excluded subjects were more likely to be women ($p \leq 0.05$) and older ($p \leq 0.001$).

### Baseline SRH and mortality: gender- and education-specific results

Table 3 presents the multivariate analyses of the association between SRH and mortality, stratified by gender and education.

In model 1, the gender-specific results indicate that baseline SRH was a strong mortality predictor in both men and women. After adjusting for health behaviors, morbidity indicators and ADL disability (Model 2), SRH was a significant predictor of mortality in men, but lost its significance in women.

In the analysis stratified by education, the association between SRH and mortality was stronger in those individuals who could read and write than in the illiterate group (Model 1). After adjusting for morbidity, ADL disability, and health behaviors (Model 2), SRH at baseline was a strong mortality predictor in individuals who could read and write: the hazard ratio for fair and poor versus good perceptions of health were 1.42 (95% CI = 1.12–1.79) and 2.22 (95% CI = 1.57–3.16), respectively. Among the illiterate group, SRH was not significantly associated with mortality.

The hazard ratio for poor SRH in women in the fully adjusted model was lower than the lower confidence limits for men, and the hazard ratios for poor SRH in men was higher than the upper confidence limits for women. With respect to education, the estimates for fair and poor SRH in illiterate persons in the fully adjusted model are well outside the CIs for fair and poor SRH in those with some education. These findings confirm gender and education

**Table 1** Baseline sociodemographic, health and functional indicators, and health behavior characteristics

| | Categories | Gender | | | Education | | | |
|---|---|---|---|---|---|---|---|---|
| | | Male ($n = 513$) | Female ($n = 503$) | $p$ value | Illiterate ($n = 155$) | Incomplete Primary ($n = 653$) | Complete Primary ($n = 208$) | $p$ value |
| Age (median (IR)) | | 73.8 (68.5–79.0) | 73.8 (68.9–78.7) | 0.782 | 75.8 (70.6–80.8) | 73.8 (68.8–78.6) | 72.5 (67.9–77.9) | ≤0.05 |
| Gender (%) | Male | – | – | – | 29.0 | 50.7 | 65.9 | ≤0.001 |
| | Female | – | – | – | 71.0 | 49.3 | 34.1 | |
| Education (%) | Complete primary | 26.7 | 14.1 | ≤0.001 | – | – | – | – |
| | Incomplete primary | 64.5 | 64.0 | | – | – | – | – |
| | Illiterate | 8.8 | 21.9 | | – | – | – | – |
| Marital status (%) | Married | 84.6 | 44.9 | ≤0.001 | 49.0 | 66.6 | 71.6 | ≤0.001 |
| | Others[a] | 15.4 | 55.1 | | 51.0 | 33.4 | 28.4 | |
| Comorbidity (median (IR)) | | 2.0 (1.0–3.0) | 3.0 (2.0–4.0) | ≤0.001 | 3 (2–4) | 2 (1–3) | 2 (1–3) | ≤0.001 |
| Depressive symptoms (CES-D) (%) | <16 | 86.4 | 60.8 | ≤0.001 | 60.6 | 74.1 | 82.2 | ≤0.001 |
| | ≥16 | 13.6 | 39.2 | | 39.4 | 25.9 | 17.8 | |
| Cognitive function score (PCL) (%) | <23 (Dementia) | 19.5 | 25.2 | ≤0.050 | 44.5 | 19.8 | 13.9 | ≤0.001 |
| | ≥23 (Normal) | 80.5 | 74.8 | | 55.5 | 80.2 | 86.1 | |
| ADL disability (%) | Able | 84.6 | 71.4 | ≤0.001 | 62.6 | 79.0 | 86.5 | ≤0.001 |
| | Able with help | 12.3 | 23.7 | | 24.5 | 17.8 | 13.5 | |
| | Disabled | 3.1 | 5.0 | | 12.9 | 3.2 | 0.0 | |
| Smoking (%) | No smoker | 18.5 | 96.6 | ≤0.001 | 73.5 | 56.4 | 47.6 | ≤0.001 |
| | Ex-smoker | 59.3 | 1.8 | | 17.4 | 31.7 | 38.0 | |
| | Smoker | 22.2 | 1.6 | | 9.0 | 11.9 | 14.4 | |
| Physical activity (%) | Vigorous | 3.5 | 2.2 | ≤0.001 | 1.9 | 3.4 | 1.9 | ≤0.001 |
| | Moderate | 77.8 | 65.8 | | 59.4 | 72.7 | 78.4 | |
| | Little | 18.7 | 32.0 | | 38.7 | 23.9 | 19.7 | |

*ADL* activities of daily living, *IR* interquartile range, CES-D Centre for Epidemiologic Study Depression Scale, PCL Prueba Cognitiva de Lenages

[a] Without spouse

**Table 2** Distribution of SRH and of persons missing or deceased at each of the first three waves of the study

| | Total | | Male | | Female | | $p$ value | |
|---|---|---|---|---|---|---|---|---|
| Self-rated health (1993) | $N_{1993} = 1{,}016$ | | $N_{1993} = 513$ | | $N_{1993} = 503$ | | ≤0.001 | |
| Good | 31.3 | | 39.8 | | 22.7 | | | |
| Fair | 51.7 | | 48.5 | | 54.9 | | | |
| Poor | 17.0 | | 11.7 | | 22.5 | | | |
| Self-rated health (1995) | $N_{1993} = 1{,}016$ | $N_{1995} = 784$ | $N_{1993} = 513$ | $N_{1995} = 402$ | $N_{1993} = 503$ | $N_{1995} = 382$ | ≤0.001 | ≤0.001 |
| Good | 24.3 | 35.6 | 31.2 | 44.3 | 17.3 | 26.4 | | |
| Fair | 35.1 | 48.9 | 32.7 | 45.2 | 37.6 | 52.6 | | |
| Poor | 10.6 | 15.6 | 6.6 | 10.4 | 14.7 | 20.9 | | |
| Missing[a] | 23.7 | – | 21.6 | – | 25.8 | – | | |
| Deceased | 6.2 | – | 7.8 | – | 4.6 | – | | |
| Self-rated health (1997) | $N_{1993} = 1{,}016$ | $N_{1997} = 632$ | $N_{1993} = 513$ | $N_{1997} = 329$ | $N_{1993} = 503$ | $N_{1997} = 303$ | ≤0.001 | ≤0.001 |
| Good | 21.5 | 37.0 | 25.1 | 42.9 | 17.7 | 30.7 | | |
| Fair | 24.0 | 41.0 | 24.6 | 40.4 | 23.5 | 41.6 | | |
| Poor | 12.2 | 22.0 | 9.2 | 16.7 | 15.3 | 27.7 | | |
| Missing[a] | 32.0 | – | 28.1 | – | 36.0 | – | | |
| Deceased | 10.3 | – | 13.1 | – | 7.6 | – | | |

[a] Persons not participating in that wave

**Table 3** Relative hazards and confidence intervals (CIs) from proportional hazards models of mortality without time-dependent covariates (TDCs): gender- and education-specific results

| Independent variable (reference category or range) | Category | Gender | | | | Education | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male ($n = 513$) | | Female ($n = 503$) | | Illiterate ($n = 155$) | | Some education ($n = 861$) | |
| | | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| Self-rated health (good) | Fair | **1.42**** | **1.36*** | **1.59**** | 1.27 | 1.33 | 0.99 | **1.46***** | **1.34*** |
| | | **(1.12–1.80)** | **(1.06–1.74)** | **(1.13–2.23)** | (0.89–1.82) | (0.76–2.34) | (0.53–1.86) | **(1.19–1.80)** | **(1.07–1.66)** |
| | Poor | **2.63***** | **2.52***** | **2.14***** | 1.49 | **1.89*** | 1.21 | **2.38***** | **2.08***** |
| | | **(1.90–3.65)** | **(1.73–3.67)** | **(1.46–3.13)** | (0.96–2.31) | **(1.02–3.51)** | (0.58–2.52) | **(1.82–3.11)** | **(1.53–2.83)** |

*Notes*: The level of statistical significance for self-rated health is from the overall $p$ value for self-rated health. All model values are hazard ratios (95% confidence interval)

Model 1: Cox regression adjusted for age, gender or education, and marital status

Model 2: Cox regression adjusted for variables in Model 1 plus chronic conditions, ADL disability, cognitive function, depressive symptoms, smoking and physical activity

*ADL* activities of daily living

Bold values indicate the significant variables in the analysis

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$

differences in the ability of SRH to predict mortality in this population.

## SRH as a TDC and mortality: gender- and education-specific results

The gender- and education-specific results from the analyses considering SRH as a TDC are presented in Table 4. In these analyses, number of chronic conditions and ADL disability were TDCs.

In model 1, SRH–TDC was associated with mortality in both men and women. After adjusting for variables at baseline (socio-demographics, health behaviors, cognitive function, and depression) and TDCs (chronic conditions and ADL disability), SRH–TDC was a significant predictor of mortality in men but not in women (Model 2).

**Table 4** Relative hazards and confidence intervals (CIs) from proportional hazards models of mortality with various time-dependent covariates (TDCs): gender- and education-specific results

| Independent variable (reference category or range) | Category | Gender | | | | Education | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male ($n = 513$) | | Female ($n = 503$) | | Illiterate ($n = 155$) | | Some education ($n = 861$) | |
| | | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| Baseline self-rated health (Good) | Fair | **1.59*** ** | **1.49** ** | **1.63** ** | 1.28 | 1.24 | 0.93 | **1.61*** ** | **1.42** ** |
| | | **(1.23–2.04)** | **(1.13–1.98)** | **(1.15–2.30)** | (0.88–1.86) | (0.69–2.23) | (0.48–1.80) | **(1.30–2.00)** | **(1.12–1.79)** |
| | Poor | **3.19*** ** | **2.82*** ** | **2.36*** ** | 1.50 | **2.18*** | 1.33 | **2.85*** ** | **2.22*** ** |
| | | **(2.23–4.56)** | **(1.81–4.40)** | **(1.57–3.55)** | (0.93–2.42) | **(1.12–4.27)** | (0.59–3.01) | **(2.14–3.82)** | **(1.57–3.16)** |
| Changes in self-rated health | | **1.39*** ** | **1.30** ** | 1.12 | 1.01 | 1.21 | 1.12 | **1.32*** ** | **1.22*** |
| | | **(1.17–1.65)** | **(1.09–1.57)** | (0.91–1.40) | (0.80–1.27) | (0.87–1.69) | (0.79–1.58) | **(1.14–1.54)** | **(1.04–1.42)** |
| Time interval[a] | | **0.82*** ** | **0.81*** ** | **0.82*** ** | **0.82*** ** | **0.80*** ** | **0.75*** ** | **0.82*** ** | **0.82*** ** |
| | | **(0.77–0.87)** | **(0.76–0.87)** | **(0.76–0.88)** | **(0.76–0.88)** | **(0.72–0.89)** | **(0.66–0.85)** | **(0.78–0.86)** | **(0.78–0.87)** |

*Notes*: The level of statistical significance for self-rated health is from the overall $p$ value for self-rated health. All model values are hazard ratios (95% confidence interval)

Model 1: Cox regression adjusted for age, gender or education, and marital status

Model 2: Cox regression adjusted for variables in Model 1 plus chronic conditions-TDC, ADL disability-TDC, cognitive function, depressive symptoms, smoking and physical activity

*TDC* time-dependent covariate, *ADL* activities of daily living

Bold values indicate the significant variables in the analysis

[a] Difference between the two dates, in years, with decimals

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$

Among the illiterate group, SRH as a TDC was a significant predictor of mortality in model 1, but not in model 2. In model 1, the hazard ratio was 1.89 (95% CI = 1.02–3.51) when we compared poor SRH–TDC with good SRH–TDC. Among those who could read and write, SRH–TDC was a strong predictor of mortality in both models.

In men and in those who could read and write, changes in SRH were significant predictors of mortality, indicating that assessment of changes in SRH during follow-up adds to the predictive value of baseline SRH.

At least one of the estimates for SRH–TDC in women and in illiterate subjects was well outside the CIs for SRH–TDC in men and for those with some education. These results confirm the ability of SRH–TDC to predict mortality in men and among those who can read and write, but these results were not found in women or in the illiterate population.

## Discussion

The objectives of this study were to examine the predictive values for mortality of SRH and SRH as a dynamic evaluation in men and women and according to education in a population of Mediterranean older people. Our results confirm that SRH reflects a dynamic evaluation of health status and that this measure is an independent predictor of mortality. After adjustment for covariates assessed at baseline (socio-demographic variables, health behaviors, cognitive function, and depression) and other TDCs (number of chronic conditions and ADL disability), SRH and SRH–TDC were significantly associated with mortality in men and in people who can read and write, but this association was not found either in women or in the illiterate population.

Consistent with the findings of Mossey and Shapiro (1982) in their pioneer paper on the Canadian older population of Manitoba, our results show that baseline physical and mental co-morbidity has weaker associations with mortality than SRH. In addition, baseline ADL disability was not significantly associated with mortality once SRH was taken into account. Our findings suggest that SRH has a short- and long-term predictive value that should be taken into account by health care providers and, in particular, by primary care physicians when monitoring the health status of their patients. Our study supports statements by previous researchers that global ratings of one's own health capture aspects of health status beyond what is assessed by objective health indicators (Jylha 2009).

Our results agree with the dynamic nature of self ratings of health advanced by Ferraro and Kelley-Moore (2001). Older people in Leganes seemed to be able to integrate variations of their health status in their ratings. Our study

has similarities with a Finnish longitudinal study which examined the impact of SRH as a TDC on mortality in older persons (Lyyra et al. 2009). These authors found a significant association with increased mortality in a 10-year follow-up in women over 75. In addition, our study is consistent with the study by Strawbridge and Wallhagen (1999), which showed that SRH as a TDC was predictive of mortality in older people. Ferraro and Kelley-Moore (2001) found that SRH–TDC was associated with mortality in white and black people. Lastly, our study is one of the few to examine the predictive ability of deterioration of perceived health status while extensively controlling for socio-demographic variables, health behaviors and concomitant physical and mental co-morbidity and disability in a population of older people (Han et al. 2005). However, since the changes in SRH were evaluated over a relative short period of time (4 years) compared with the long follow-up of mortality (15 years), in our study time-varying (or dynamic) SRH does not greatly improve the predictive power of SRH above baseline measurement of SRH.

Deeg and Kriegsman found that SRH was a predictor of mortality at 3 and 7 years of follow-up in men but not in women (Deeg and Kriegsman 2003). They argued that since women suffer from more disabling chronic diseases than men, they may tend to base their judgment more on disability than on mortality risk, whereas the opposite may occur with men, who are at higher risk of presenting high-mortality conditions such as heart disease. First, women may have a higher prevalence of poor health precisely because they suffer more disabling conditions such as arthritis, obesity, osteoporosis, and depression as compared with men. Second, their judgment of their health status may be based more on disability than on the lethality of their conditions. Men, on the contrary, are more likely to be affected by high-mortality diseases like cancer and heart disease, and may base their health on their mortality risk. A complementary explanation was given by Idler (Idler 2003). She stated that women are more aware of every aspect of their health status, and therefore, the association of SRH with mortality decreases or disappears completely for women, after adjusting for variables related with health and disability. This is precisely what happens in our analyses, since SRH predicts mortality in model 1 (controlling for socio-demographics) but not in model 2 (controlling for health behaviors, health indicators and disability).

Concerning the impact of education on the predictive value of SRH for mortality, Regidor et al. (2010) have suggested that those with lower education may be less aware of non-life threatening conditions than people with high education. An alternative explanation would be that people with the ability to read can get better information during their life course on the determinants of good health and on the lethality of chronic diseases. This information may lead to a more accurate judgment of SRH compared with those who are illiterate.

Among the limitations of this study we must cite the lack of medical diagnosis and information about the severity of chronic diseases. Had this information been available, we would have been able to construct a "burden of comorbidity" scale to assess if changes in SRH followed incident or more severe co-morbidity in the chain of causality between deteriorating health and death. In addition, the relatively small sample size did not allow us to further disaggregate causes of mortality or to distinguish cardiovascular from other causes of death.

## Conclusion

This study contributes to the literature by adding evidence on the validity of SRH and on the dynamic nature of SRH in a Mediterranean population of older people characterized by high longevity, low education, and gender-stratified upbringing. In Spain, illiteracy is gradually disappearing, even among those aged 65 and over, and gender equality is increasing. Considering these large societal changes, it may be appropriate for health professionals to ask their patients, regardless of gender and literacy, to rate both their current and previous health status since a decline may indicate an increased mortality risk.

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