Int J Public Health (2010) 55:279–289
DOI 10.1007/s00038-010-0121-z

ORIGINAL ARTICLE

Self-rated health and mortality: gender- and age-specific contributions of explanatory factors in South Korea

Young-Ho Khang · Hye Ryun Kim

Received: 26 September 2008 / Revised: 1 June 2009 / Accepted: 12 January 2010 / Published online: 9 February 2010

Abstract

Objectives This study explored gender- and age-specific contributions of explanatory factors to the relationship between self-rated health (SRH) and all-cause mortality.

Methods We used mortality follow-up data from 1998 and 2001 National Health and Nutrition Examination Surveys of South Korea ($n = 9{,}663$). Explanatory factors included baseline health status, socioeconomic status, health behaviors, clinical risk factors, psychosocial factors, and family medical history.

Results The ability of explanatory factors to explain the SRH–mortality relationship differed with age. For those aged 30–64, most excess hazards were explained by all explanatory factors. However, a large part of the mortality differentials by SRH remained unexplained among elderly samples.

Conclusions A wide range of health-related factors could explain the SRH–mortality association in younger population but not in older population. Factors to explain a large part of mortality differentials by SRH among older population should be identified.

Keywords Age · Gender · Korea · Mortality · Self-rated health

Y.-H. Khang (✉)
Department of Preventive Medicine,
University of Ulsan College of Medicine,
388-1 Pungnap-2Dong, Songpa-Gu, Seoul 138-736, Korea
e-mail: youngk@amc.seoul.kr
URL: http://cms.ulsan.ac.kr/youngk/

H. R. Kim
Korea Institute for Health and Social Affairs, Seoul, Korea

Introduction

As a single item, self-rated health (SRH) has been frequently used as a measure for health status in epidemiological research. This practice is based on studies indicating a close relation of SRH with mortality (Benyamini and Idler 1999; Idler and Benyamini 1997). Although it is clear that SRH can be a potentially good measure for health status, what SRH exactly measures is not well-known (Singh-Manoux et al. 2006; Svedberg et al. 2006).

Gender- and age-specific patterns in the SRH–mortality association may aid us in understanding the meaning of SRH. A closer examination about gender and age differences in effects of SRH on mortality has been proposed (Deeg and Bath 2003; Idler et al. 2000). Health and health behavior profiles as well as social and psychological conditions clearly differ with gender and age (Danielsson and Lindberg 2001; Calasanti and Slevin 2001; Davey 1995). Sensitivity to signs and symptoms of illnesses and health-related conditions may also vary with gender and age. Thus, 'healthy' and 'unhealthy' status may mean something different to gender and age groups. If a certain factor is more highly correlated with SRH in a gender or age subgroup compared with other gender or age groups, the factor can better explain the association between SRH and mortality in the gender or age group than other subgroups. Furthermore, a strong mortality predictor related with SRH may better explain the SRH–mortality relationship than a predictor less strongly associated with mortality. Many explanatory factors have been suggested to explain the SRH–mortality association. Several studies have examined factors such as health behaviors (Benjamins et al. 2004), psychosocial factors (Larsson et al. 2002; Mackenbach et al. 2002), baseline health status, socioeconomic status, cardiovascular risk factors (Heidrich et al. 2002; Kaplan et al. 1996), and family history of chronic disease (Pijls et al. 1993). Although the magnitude of SRH–mortality association by gender and age has been often examined, investigations into the contribution of a wide range of explanatory factors to the SRH–mortality relationship by gender and age have rarely been performed.

Thus, the aim of this study was to explore the gender- and age-specific contributions of baseline health, socio-economic status, health behaviors, clinical risk factors, psychosocial factors, and family medical history to the relationship between SRH and all-cause mortality. To examine these questions, we used mortality follow-up data of a nationally representative sample of South Koreans, available through the 1998 and 2001 National Health and Nutrition Examination Survey (NHANES) of South Korea.

Methods

Study subjects

This study was approved by the Institutional Review Board of the Asan Medical Center, Seoul, South Korea.

We pooled data from the two NHANES surveys (1998 and 2001) conducted by the Korea Institute for Health and Social Affairs. Information was collected from a stratified multistage probability sample of South Korean households representing the civilian, non-institutionalized population. Additional details regarding study design and methods are provided elsewhere (Khang and Kim 2005a; Khang et al. 2009; MOHW 1999, 2002). A total of 11,969 men and women aged 30+ participated in the health examination surveys of the 1998 and 2001 NHANES. Of those, 10,437 reported valid 13-digit personal identification numbers which were linked to data on mortality from the National Statistical Office of Korea (NSO). All deaths of Koreans must be reported to NSO by law and death certification data among South Korean adults are known to be complete (Khang et al. 2004). We excluded respondents lacking a SRH variable ($n = 525$, 5.0%). Of the remaining 9,912 subjects, we also excluded respondents lacking any explanatory variable ($n = 249$, 2.4%) in our analysis. Dummy variables were given for the two major missing variables: income ($n = 221$) and blood pressure ($n = 335$). Of the remaining 9,663 (92.6% of 10,437) respondents aged 30+, 439 died through December 2005.

Variables on SRH and death

One question regarding SRH was included in this study ('How would you rate your health as compared to that of others your age?') with a five-point Likert scale answer category ranging from 1 = 'very good' to 5 = 'very poor'. For gender- and age-specific analyses, we combined 'very good', 'good', and 'fair' SRH groups as the reference and grouped 'poor' and 'very poor' SRH groups as the risk group. This categorization was plausible because the mortality risks for 'very good', 'good', and 'fair' SRH groups were similar (see Table 1).

The outcome variable for this study was all-cause mortality. Further detailed cause-specific analyses were not possible due to small number of deaths for each cause.

Explanatory variables

Several variables were chosen as explanatory variables. These explanatory variables were basically based on the factors suggested by Idler and Benyamini (1997). These variables have been shown to be predictive of survival in prior Korean studies (Khang and Kim 2005a; Khang et al. 2009).

Baseline health

By means of a checklist of 37 (in 1998) and 53 (in 2001) chronic conditions, we identified respondents with physician-diagnosed chronic illnesses during the past year. We grouped ten severe physician-diagnosed chronic diseases at baseline as severe chronic disease (cancer, diabetes, stroke, ischemic heart disease, other heart diseases, chronic obstructive pulmonary disease, chronic liver disease, chronic renal disease, dementia, and pulmonary tuberculosis). The number of severe chronic diseases was used as the baseline health indicator in this study.

Socioeconomic status

Education, occupational class, and household income were used as indicators for socioeconomic status in this study. Education level was determined by completion and grouped as no formal education, primary school, middle school, high school or over. Occupational class categories of non-manual versus manual were employed. Those who were not in the labor force (unemployed, retired, students and homemakers) were categorized as others. Personal occupation was used for both men and women to define occupational class. Household income was measured as combined income from all sources of the respondent and his or her family members. Considering the absolute income difference between survey years, consumer price index by year was used to produce the equivalent house-hold income for the year 2000. Household income was then grouped into five categories: $≥30,000 (8.9% of all participants); $20,000–$29,999 (16.5%); $10,000–$19,999 (37.7%); $<10,000 (33.6%) (1 US$ = 1,200 Korean Won); unknown (2.3%).

Table 1 Number of subjects, deaths, and relative hazard (RH) of all-cause mortality by categories of self-rated health: 1998/2001 National Health and Nutrition Examination Survey of South Korea ($n = 9{,}663$)

	No. of subjects (no. of deaths)	RH (95% CI)	RH (95% CI)
Men aged 30+[a]	4,410 (262)		
Very good	279 (10)	1.00 (reference)	1.00 (reference)
Good	1,685 (67)	1.07 (0.55–2.07)	
Fair	1,621 (58)	1.09 (0.56–2.13)	1.03 (0.73–1.45)
Poor	681 (88)	2.27 (1.18–4.37)	2.15 (1.58–2.93)
Very poor	144 (39)	4.58 (2.28–9.22)	4.34 (2.93–6.42)
Women aged 30+[a]	5,253 (177)		
Very good	196 (3)	1.00 (reference)	1.00 (reference)
Good	1,708 (39)	0.95 (0.29–3.09)	
Fair	1,740 (24)	0.98 (0.30–3.26)	1.02 (0.62–1.71)
Poor	1,319 (76)	1.87 (0.59–5.96)	1.96 (1.33–2.87)
Very poor	290 (35)	3.12 (0.95–10.17)	3.26 (2.07–5.13)
Men and women aged 30–64[b]	8,215 (180)		
Very good	436 (7)	1.00 (reference)	1.00 (reference)
Good	2,981 (45)	0.95 (0.43–2.10)	
Fair	3,058 (48)	1.02 (0.46–2.25)	1.06 (0.72–1.57)
Poor	1,474 (59)	2.05 (0.93–4.51)	1.75 (1.20–2.55)
Very poor	266 (21)	3.77 (1.58–8.98)	2.97 (1.78–4.97)
Men and women aged 65+[b]	1,448 (259)		
Very good	39 (6)	1.00 (reference)	1.00 (reference)
Good	412 (61)	1.18 (0.51–2.75)	
Fair	303 (34)	1.07 (0.45–2.56)	0.97 (0.64–1.47)
Poor	526 (105)	2.20 (0.96–5.04)	1.74 (1.28–2.37)
Very poor	168 (53)	4.22 (1.80–9.90)	3.21 (2.23–4.62)

[a] Survey year and age were adjusted for

[b] Survey year, gender, and age were adjusted for

Health behaviors

Four categories of cigarette smoking status were used in this study including ‘never smoked’, ‘former smoker’, ‘irregular smoker’, and ‘daily smoker’. Alcohol consumption was measured by questions on the current status of drinking and classified into five categories of ‘never drinker’, ‘former drinker’, ‘minimal drinker’, ‘often drinker’, and ‘frequent drinker’. Regular physical exercise was measured by asking whether respondents exercised regularly in the past month, with response choices of ‘yes’ and ‘no’.

Clinical risk factors

Blood pressure (mmHg) was calculated as the mean of two successive readings. Blood pressure was classified as normal (systolic BP < 120 mmHg; diastolic BP < 80 mmHg), pre-hypertension (systolic BP 120–139 mmHg; diastolic BP 80–89 mmHg), and hypertension (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg). Serum total cholesterol and glucose levels were measured after an overnight fast, using an autoanalyzer (Hitachi 747; Daiichi, Tokyo, Japan). Levels of total cholesterol (mmol/L) were grouped into categories of less than 5.2, 5.2–6.1, and 6.2 or over. Fasting serum glucose (mmol/L) was grouped as less than 7.0 and 7.0 or over. Body mass index (BMI) was calculated by dividing body weight by height squared (kg/m^2) and grouped into four categories of less than 18.5, 18.5 through 22.9, 23.0 through 27.4, and 27.5 or over (WHO Expert Consultation 2004). Hepatitis B surface antigen (HBsAg) status was determined by ELISA tests (CODA of BIO-RAD Company, California, USA).

Psychosocial factors

Subjects were asked to report the frequency of feelings of sadness and depression during the past year. Responses were grouped into four categories of ‘none’, ‘rare’, ‘often’, and ‘always’. Perceived level of stress was measured with a single question and response choice of ‘nearly none’, ‘low’, ‘high’, and ‘very high’. Marital status has been used as an important measure for social support (Berkman and Glass 2000) and was included in this study as a psychosocial factor. Marital status was categorized as married or unmarried.

Family history

For the 1998 and 2001 NHANES, participants were asked to report whether parents, grandparents, or siblings had hypertension, stroke, ischemic heart disease (angina or myocardial infarction), heart failure, liver disease, and diabetes. For hypertension, stroke, ischemic heart disease, and heart failure, only those cases developing before 50 years of age were considered as having a family history of those diseases. Participants whose parents, grandparents, or siblings had any of these diseases were grouped as having family medical history.

Statistical analysis

Cox proportional hazard models were used to estimate relative hazards (RHs) and their 95% confidence intervals (CIs) of all-cause mortality by SRH, adjusted for survey year (1998 and 2001) and age (age and age square). This analysis was done for men and women separately and for those aged 30–64 and 65+. RH by explanatory variables was also presented using Cox's regression. Survey year- and age-standardized percentages of respondents in selected explanatory variables by SRH categories were calculated with direct standardization method. The total number of subjects was the reference. CIs of survey year- and age-standardized percentages were estimated. We then explored the role of baseline health status, socioeconomic status, health behaviors, clinical risk factors, psychosocial factors, and family medical history in the SRH–mortality relationship. For this, we calculated the percent change in RH for SRH variable due to the inclusion of specific explanatory variables to the baseline model adjusting for survey year and age. Several studies exploring the role of explanatory variables to the SRH–mortality relationship reported changes in RH for SRH before and after the adjustment of the explanatory variables (Benjamins et al. 2004; Heidrich et al. 2002; Heistaro et al. 2001; Mackenbach et al. 2002). A prior Swedish study used the percent change in RH as a measure for explanatory ability in the SRH–mortality relationship (Larsson et al. 2002). Bootstrapping methods (1,000 bootstrap samples) were employed to estimate the 95% CIs for these explanatory abilities. All statistical analyses were performed with SAS statistical software, with a p value of 0.05 considered statistically significant.

Results

The study cohort contained 55,061 person-years of follow-up (average length of follow-up = 5.7 years). Of 439 total deaths, male deaths accounted for 59.7% ($n = 262$) and deaths among those aged 65+ accounted for 59.0% ($n = 259$). Cancer ($n = 114$), cardiovascular disease ($n = 112$), external causes ($n = 53$), and other causes ($n = 160$) accounted for 26.0, 25.5, 12.1, and 36.4% of deaths, respectively.

As shown in Table 1, an increase in all-cause mortality hazard by categories of SRH was found. RHs for the 'poor' and 'very poor' categories were statistically significant compared to the 'very good' category. However, mortality hazards for the 'good' and 'fair' categories were similar to that for the 'very good' category in both genders. The magnitude of RH in men for each category of SRH tended to be greater than that in women, but the RH difference by gender was not statistically significant (interaction between ordinal SRH variable and gender: $p = 0.336$). Table 1 also presents the relationship between SRH and mortality hazard in both age groups of 30–64 and 65 or over. Results showed that RHs for the 'very poor' category were statistically significant in both age groups. The interaction between ordinal SRH variable and broad age groups (30–64 and 65+) was not significant (interaction test $p = 0.478$).

Table 2 presents survey year-, gender-, and age-adjusted RH of all-cause mortality by a wide range of explanatory variables. Considering the small number of deaths for each category of explanatory variables (e.g., the no. of deaths among women aged 30–64 was 55) and space limitations, we combined women and men (gender- and age-specific analysis results are available upon request). Generally, more explanatory variables were significantly associated with all-cause mortality among younger age groups than among older age groups. The number of severe chronic disease was a significant predictor of mortality especially among men and women aged 30–64. Mortality risk among those aged 30–64 with two or more severe chronic diseases was 6.07 times greater (95% CI 3.52–10.44) than those aged 30–64 without any severe chronic disease. Variables for socioeconomic status were significantly associated with mortality among men and women aged 30–64 while no significant relationships were found among those aged 65+. Similar patterns (i.e., significant associations among those aged 30–64 but no significant associations among those aged 65+) were presented for most clinical risk factors (blood pressure, serum total cholesterol, fasting serum glucose, and HBsAg). However, relatively similar significant associations between health behaviors (cigarette smoking, alcohol consumption, and regular physical exercise) and all-cause mortality were found among both younger and older age groups. Similar significant associations were shown for stress variable among both younger and older age groups. However, marital status was a significant predictor of mortality in younger age groups but not in older age groups. The relationship between family

Table 2 Survey year-, gender-, and age-adjusted relative hazard (95% confidence intervals) of all-cause mortality by baseline health status, socioeconomic status, health behaviors, clinical risk factors, psychosocial factors, and family history: 1998/2001 National Health and Nutrition Examination Survey of South Korea

	Men and women aged 30–64		Men and women aged 65+	
	No. of subjects (no. of deaths)	RH (95% CI)	No. of subjects (no. of deaths)	RH (95% CI)
Baseline health status				
No. of severe chronic disease				
None	7,164 (127)	1.00 (reference)	1,022 (166)	1.00 (reference)
1	947 (38)	1.71 (1.18–2.47)	356 (81)	1.60 (1.22–2.08)
2 or more	104 (15)	6.07 (3.52–10.44)	70 (12)	1.58 (0.88–2.85)
Socioeconomic status				
Educational level				
High school or over	4,878 (59)	1.00 (reference)	181 (21)	1.00 (reference)
Middle school	1,432 (33)	1.32 (0.85–2.04)	115 (16)	1.11 (0.58–2.14)
Primary school	1,501 (64)	1.78 (1.19–2.65)	441 (73)	1.33 (0.81–2.18)
No formal education	404 (24)	2.59 (1.48–4.54)	711 (149)	1.51 (0.92–2.50)
Occupational class				
Non-manual	1,239 (8)	1.00 (reference)	17 (3)	NA
Manual	4,336 (108)	2.69 (1.30–5.57)	469 (60)	NA
Not in the labor force	2,640 (64)	4.01 (1.87–8.59)	962 (196)	NA
Annual household income (US dollar)				
30,000 or over	806 (8)	1.00 (reference)	54 (8)	1.00 (reference)
20,000–29,999	1,495 (22)	1.44 (0.64–3.23)	104 (16)	1.19 (0.51–2.79)
10,000–19,999	3,465 (63)	1.75 (0.84–3.64)	276 (51)	1.58 (0.75–3.32)
Less than 10,000	2,260 (87)	2.28 (1.10–4.75)	982 (180)	1.47 (0.72–2.99)
Unknown	189 (0)	NA	32 (4)	1.81 (0.53–6.14)
Health behaviors				
Cigarette smoking				
Never smoked	4,872 (64)	1.00 (reference)	765 (93)	1.00 (reference)
Former smoker	715 (21)	1.19 (0.65–2.19)	270 (64)	1.61 (1.11–2.33)
Irregular smoker	162 (5)	1.99 (0.76–5.18)	27 (6)	1.54 (0.67–3.53)
Daily smoker	2,466 (90)	1.71 (1.07–2.74)	386 (96)	1.81 (1.31–2.51)
Alcohol consumption				
Never drinker	2,259 (54)	1.00 (reference)	710 (110)	1.00 (reference)
Former drinker	286 (26)	2.12 (1.28–3.50)	167 (54)	1.72 (1.21–2.45)
Minimal drinker	1,770 (13)	0.43 (0.23–0.79)	202 (26)	0.80 (0.52–1.23)
Often drinker	2,463 (44)	0.80 (0.51–1.24)	180 (31)	1.04 (0.69–1.57)
Frequent drinker	1,437 (43)	0.82 (0.51–1.30)	189 (38)	1.13 (0.75–1.69)
Regular physical exercise				
Yes	1,952 (33)	1.00 (reference)	285 (32)	1.00 (reference)
No	6,263 (147)	1.33 (0.91–1.94)	1,163 (227)	1.52 (1.04–2.21)
Clinical risk factors				
Blood pressure (mmHg)				
Normal (SBP $<$ 120, DBP $<$ 80)	3,207 (38)	1.00 (reference)	235 (38)	1.00 (reference)
Pre-hypertension (SBP 120–139, DBP 80–89)	2,965 (66)	1.22 (0.82–1.83)	459 (81)	0.90 (0.61–1.32)
Hypertension (SBP $\geq$ 140, DBP $\geq$ 90)	1,758 (71)	1.55 (1.04–2.32)	701 (136)	1.06 (0.74–1.53)
Unknown	285 (5)	2.84 (1.05–7.70)	53 (4)	0.65 (0.23–1.86)
Serum total cholesterol (mmol/L)				
Less than 5.2	5,241 (118)	1.00 (reference)	794 (152)	1.00 (reference)
5.2–6.1	2,247 (38)	0.62 (0.43–0.89)	483 (79)	0.90 (0.68–1.18)
6.2 or over	727 (24)	1.07 (0.69–1.66)	171 (28)	1.00 (0.66–1.51)

Table 2 continued

	Men and women aged 30–64		Men and women aged 65+	
	No. of subjects (no. of deaths)	RH (95% CI)	No. of subjects (no. of deaths)	RH (95% CI)
Fasting serum glucose				
7.0 or less	7,573 (142)	1.00 (reference)	1,263 (221)	1.00 (reference)
7.0 or over	642 (38)	1.95 (1.36–2.80)	185 (38)	1.28 (0.91–1.81)
Body mass index (kg/m^2)				
Less than 18.5	244 (15)	2.12 (1.22–3.66)	127 (45)	1.35 (0.96–1.91)
18.5–22.9	3,356 (88)	1.00 (reference)	639 (133)	1.00 (reference)
23.0–27.4	3,749 (69)	0.68 (0.50–0.94)	562 (68)	0.71 (0.53–0.95)
27 or over	866 (8)	0.39 (0.19–0.80)	120 (13)	0.77 (0.43–1.38)
Hepatitis B surface antigen (HBsAg)				
Negative	7,754 (163)	1.00 (reference)	1,415 (253)	1.00 (reference)
Positive	461 (17)	1.87 (1.13–3.08)	33 (6)	1.11 (0.50–2.50)
Psychosocial factors				
Depression				
None	929 (28)	1.00 (reference)	220 (38)	1.00 (reference)
Rare	2,120 (27)	0.49 (0.29–0.83)	328 (48)	1.00 (0.65–1.53)
Often	4,433 (93)	0.96 (0.63–1.47)	609 (114)	1.27 (0.88–1.84)
Always	733 (32)	1.47 (0.88–2.45)	291 (59)	1.67 (1.10–2.52)
Perceived level of stress				
Nearly none	1,230 (30)	1.00 (reference)	567 (110)	1.00 (reference)
Low	4,011 (64)	0.99 (0.64–1.53)	448 (74)	1.03 (0.77–1.40)
High	2,427 (62)	1.50 (0.97–2.34)	337 (55)	1.10 (0.79–1.54)
Very high	547 (24)	2.37 (1.38–4.07)	96 (20)	1.67 (1.03–2.72)
Current marital status				
Married	7,298 (141)	1.00 (reference)	816 (141)	1.00 (reference)
Unmarried	917 (39)	2.64 (1.82–3.83)	632 (118)	1.18 (0.85–1.64)
Family history				
Family medical history				
No	5,814 (132)	1.00 (reference)	1,227 (223)	1.00 (reference)
Yes	2,401 (48)	1.11 (0.79–1.54)	221 (36)	1.14 (0.80–1.63)

medical history and mortality was not significant in both age groups.

Tables 3 and 4 present survey year- and age-standardized percentages of selected explanatory variables according to SRH among men and women. We only presented important categories for each variable due to space limitation (detailed data are available upon request). Generally, more variables were significantly associated with SRH in men than women and in younger than older persons. Men and women who rated their health as 'poor' or 'very poor' were more likely to have severe chronic disease (1 and 2 or more), feelings of sadness and depression (always) and perceived stress (very high). This was true for those aged 30–64 and 65+. BMI < 18.5 kg/m^2 was common in men aged 30–64 and 65+ who reported their health as 'poor' or 'very poor'. No education, low household income of <$10,000, and marital status (percentage of the unmarried) showed differences in prevalence by SRH among men and women aged 30–64 but not among those aged 65+. Men aged 30–64 who reported their health at lower levels had greater percentage of those being not in labor market and with the hepatitis B antigen. Tables 3 and 4 also show remarkable gender differences in the smoking and alcohol consumption as well as educational level.

Table 5 presents gender- and age-specific percent changes in excess RH of all-cause mortality by SRH when six different factors were adjusted for separately or simultaneously. For this, we dichotomized the SRH groups (very poor/poor vs. very good/good/fair). The percent changes in those aged 30–64 tended to be greater than in

Table 3 Survey year- and age-standardized percentage of explanatory variables according to categories of self-rated health in South Korean men: the 1998/2001 National Health and Nutrition Examination Survey of South Korea

	Men aged 30–64 (n = 3,810)		Men aged 65+ (n = 600)	
	Very good/good/fair	Poor/very poor	Very good/good/fair	Poor/very poor
1 severe chronic disease	9.0 (7.9–10.0)	24.0 (19.9–28.2)	18.5 (14.1–22.9)	37.5 (29.6–45.4)
2 or more severe chronic disease	0.6 (0.3–0.9)	4.2 (2.6–5.9)	1.0 (−0.1 to 2.1)	12.7 (8.1–17.2)
No education	1.3 (0.9–1.7)	3.0 (1.8–4.2)	25.5 (20.3–30.7)	26.3 (19.8–32.9)
Manual workers	64.1 (61.3–66.8)	65.0 (58.1–72.0)	–	–
Not in labor market	10.2 (9.1–11.3)	19.0 (15.4–22.5)	–	–
Household income < 10,000 USD	23.2 (21.5–24.9)	35.9 (31.0–40.9)	65.3 (57.0–73.6)	73.8 (62.8–84.9)
Daily smoker	59.8 (57.1–62.5)	67.7 (60.5–74.9)	43.2 (36.4–49.9)	48.0 (39.0–57.0)
Frequent alcohol drinking	33.9 (31.8–35.9)	32.7 (27.7–37.6)	28.0 (22.6–33.4)	23.5 (17.2–29.8)
No regular exercise	72.0 (69.1–74.9)	79.4 (71.7–87.2)	67.8 (59.4–76.3)	81.7 (70.1–93.3)
Hypertension, ≥140, ≥90 mmHg	26.3 (24.5–28.1)	28.3 (24.0–32.6)	43.0 (36.3–49.7)	45.3 (36.7–54.0)
Total cholesterol ≥ 240 mg/dl	9.5 (8.5–10.6)	8.1 (5.6–10.6)	4.8 (2.6–7.1)	7.3 (3.9–10.8)
Serum glucose ≥ 126 mg/dl	9.0 (7.9–10.0)	11.1 (8.3–13.9)	10.3 (7.0–13.6)	12.5 (7.9–17.1)
Body mass index < 18.5 kg/m^2	2.0 (1.5–2.5)	5.9 (3.8–7.9)	8.2 (5.2–11.1)	17.3 (11.9–22.8)
Body mass index ≥ 27.5 kg/m^2	9.7 (8.6–10.7)	9.8 (6.9–12.7)	3.8 (1.8–5.9)	3.7 (1.2–6.1)
Hepatitis B antigen positive	5.5 (4.7–6.3)	9.2 (6.5–11.9)	2.3 (0.7–4.0)	2.0 (0.2–3.8)
Depression (always)	3.5 (2.9–4.2)	17.4 (14.0–20.8)	6.0 (3.5–8.5)	26.5 (20.0–33.0)
Stress (very high)	5.0 (4.3–5.8)	15.7 (12.2–19.2)	2.5 (0.8–4.2)	11.3 (7.0–15.6)
Unmarried	8.5 (7.5–9.4)	13.5 (10.1–17.0)	10.7 (7.3–14.0)	11.3 (7.0–15.7)
Family medical history	27.2 (25.4–29.0)	33.1 (28.0–38.2)	10.7 (7.3–14.0)	16.2 (11.0–21.4)

Survey year- and age-standardized percentages of explanatory variables were calculated with adjustment to survey year- and 10-year age groups according to the direct method with the distribution of total sample as the standard. Selected categories for each variable were only presented in this table but detailed data for other categories are available upon request

those aged 65+, although bootstrapping methods yielded wide 95% CIs. This was true for men and women and true for adjustment of all factors and adjustment of each factor except for male health behaviors. For men aged 65+, health behaviors still had an important explanatory ability of SRH–mortality association. When all six factors were adjusted, 67.7% (in men aged 30–64) and 76.0% (in women aged 30–64) of excess RH decreased in the ‘very poor/poor’ category and the SRH–mortality association became insignificant (RH in men = 1.42, 95% CI 0.93, 2.17, RH in women = 1.36, 95% CI 0.71, 2.62). For those aged 65+, adjustment of all factors showed a 25.8 and 5.4% reduction of excess RH in the ‘very poor/poor’ category among men and women, respectively. When we only included more objective variables related to health (baseline health status, health behaviors, and clinical risk factors) as explanatory variables, percent changes in excess RH were substantial: 50.8% in men aged 30–64 and 53.3% in women aged 30–64. The corresponding figures for those aged 65+ were 31.9 and 8.1%, respectively. In men aged 30–64, five factors except for family history showed a modest reduction in excess RH ranging from 17.7 to 23.8% while health behaviors were most important in men aged 65+. In women aged 30–64, the role of baseline health status and socioeconomic status in percent reduction of excess RH was most important followed by clinical risk factors, health behaviors, and psychosocial factors. When education and income were used as indicators of socioeconomic status among those aged 30–64 (similarly as among those aged 65+), RHs were 2.11 (95% CI 1.45, 3.07) in men and 2.18 (95% CI 1.24, 3.83) in women: 14.6 and 21.3% changes in excess RH, respectively. Family history had no effect on the reduction of RH. This was true for men and women and true for those aged 30–64 and 65+.

Discussion

The results of this study revealed a threshold effect of SRH on all-cause mortality. Mortality hazards for ‘very good’, ‘good’ and ‘fair’ SRH were similar in men and women and in younger and older age groups. When we combined ‘very good’ and ‘good’ categories to reduce the problem of small no. of deaths in the ‘very good’ SRH category, similar threshold effects were found (Table 1). It has been known that relationships between SRH and mortality hazard showed a graded pattern (Benyamini and Idler 1999; Idler

Table 4 Survey year- and age-standardized percentage of explanatory variables according to categories of self-rated health in South Korean women: the 1998/2001 National Health and Nutrition Examination Survey of South Korea

	Women aged 30–64 (n = 4,405)		Women aged 65+ (n = 848)	
	Very good/good/fair	Poor/very poor	Very good/good/fair	Poor/very poor
1 severe chronic disease	8.4 (7.4–9.4)	20.8 (17.8–23.8)	16.5 (12.4–20.6)	29.5 (24.5–34.5)
2 or more severe chronic disease	0.2 (0.1–0.4)	4.0 (2.7–5.3)	1.3 (0.1–2.5)	6.4 (4.0–8.7)
No education	6.5 (5.5–7.5)	9.9 (8.4–11.5)	59.6 (51.9–67.2)	70.3 (62.5–78.1)
Manual workers	43.4 (41.1–45.7)	41.9 (37.8–45.9)	–	–
Not in labor market	48.7 (46.3–51.1)	54.1 (49.1–59.1)	–	–
Household income < 10,000 USD	26.3 (24.4–28.1)	38.3 (34.6–42.1)	63.9 (55.9–71.9)	69.8 (62.1–77.5)
Daily smoker	2.8 (2.2–3.4)	4.3 (3.0–5.5)	11.9 (8.5–15.3)	15.0 (11.4–18.6)
Frequent alcohol drinking	3.5 (2.8–4.1)	3.7 (2.4–5.1)	4.8 (2.6–7.1)	2.8 (1.2–4.4)
No regular exercise	77.4 (74.3–80.5)	80.5 (74.7–86.3)	81.0 (72.0–90.0)	88.3 (79.7–97.0)
Hypertension, ≥140, ≥90 mmHg	15.9 (14.4–17.3)	18.3 (16.0–20.6)	48.8 (41.9–55.8)	53.9 (47.1–60.7)
Total cholesterol ≥ 240 mg/dl	9.0 (7.9–10.2)	8.4 (6.7–10.0)	16.3 (12.3–20.2)	14.6 (11.1–18.1)
Serum glucose ≥ 126 mg/dl	5.9 (5.0–6.8)	8.6 (6.8–10.4)	10.3 (7.1–13.4)	16.6 (12.9–20.4)
Body mass index < 18.5 kg/m^2	2.7 (2.2–3.3)	4.4 (2.9–6.0)	4.4 (2.4–6.4)	8.7 (5.9–11.5)
Body mass index ≥ 27.5 kg/m^2	11.5 (10.3–12.7)	12.4 (10.1–14.7)	8.3 (5.4–11.1)	13.9 (10.5–17.3)
Hepatitis B antigen positive	4.8 (4.0–5.5)	7.2 (5.3–9.1)	2.6 (1.0–4.2)	1.9 (0.6–3.2)
Depression (always)	6.4 (5.5–7.3)	24.8 (21.6–28.0)	12.5 (9.0–16.0)	33.8 (28.5–39.2)
Stress (very high)	4.2 (3.4–4.9)	14.0 (11.4–16.6)	2.5 (0.9–4.1)	10.5 (7.5–13.4)
Unmarried	12.1 (10.8–13.4)	16.2 (13.7–18.8)	68.5 (60.3–76.7)	64.9 (57.4–72.3)
Family medical history	29.1 (27.3–31.0)	34.7 (30.6–38.8)	14.9 (11.0–18.7)	18.4 (14.5–22.3)

Survey year- and age-standardized percentages of explanatory variables were calculated with adjustment to survey year- and 10-year age groups according to the direct method with the distribution of total sample as the standard. Selected categories for each variable were only presented in this table but detailed data for other categories are available upon request

and Benyamini 1997). However, in several Western studies, mortality hazards for 'good' SRH, compared to 'excellent' SRH, were similar or even smaller in men (Bath 2003; McCallum et al. 1994) and women (Idler et al. 2000). In a prior South Korean study (Jee et al. 1994), 'very good', 'good', and 'fair' SRH groups had similar mortality hazards.

Results of our study revealed that the explanatory ability measured by percent changes in excess RH differed with age. This age difference in the magnitude of explanatory variables to explain the SRH–mortality relationship was anticipated because (1) in Table 2 more explanatory variables were associated with mortality among men and women aged 30–64 than among men and women aged 65+ and (2) in Tables 3 and 4 more variables were associated with SRH in younger than older subjects. To the best of our knowledge, no prior study has examined age group-specific roles of health-related components to explain the SRH–mortality association. When all variables were adjusted for, the extent of explanation was greater in younger age. RH by categories of SRH became insignificant after adjustment of all factors in younger age. This finding is important because, while many prior studies tried to explain the SRH–mortality association through the use of various factors, they often failed to explain the relation 'away'. It can be criticized that the final models were over-fitted since a total of 16 explanatory variables were included in the final models. However, when we only included more objective variables related to health (baseline health status, health behaviors, and clinical risk factors), similar age differences in explanatory ability have been produced.

Several explanations can be suggested for the age differences in explanatory ability. Age-specific relationships between explanatory variables and all-cause mortality need to be first considered. As shown in Table 2, variables for baseline health status, socioeconomic position, clinical risk factors and marital status presented significant relationships with mortality among those aged 30–64 but not among those aged 65+. Age differences in explanatory ability were marked for these variables (see Table 5). Prior studies in Korea as well as Western countries showed less significant relationship between socioeconomic status and mortality among elders than young adults (Huisman et al. 2005; Khang and Kim 2005b; Khang et al. 2004). Decreasing RHs of all-cause mortality by clinical risk factors with increasing age have been reported in Korea (Khang et al. 2008). Older age groups reportedly had smaller RHs by marital status compared to their younger

Table 5 Gender- and age-specific effect of adjustment on the relative hazard (RH) of all-cause mortality by categories of self-rated health (very poor/poor vs. very good/good/fair)

	Ages 30–64		Ages 65+	
	RH (95% CI)	Percent change (95% CI)[a]	RH (95% CI)	Percent change (95% CI)[a]
Men				
No. of subjects (no. of deaths)	3,810 (125)		600 (137)	
Baseline model	2.30 (1.59–3.32)		2.63 (1.87–3.69)	
Baseline health status	2.03 (1.38–2.98)	20.8 (2.7–41.3)	2.51 (1.75–3.59)	7.4 (−15.1 to 26.4)
Socioeconomic status	2.04 (1.40–2.96)	20.0 (5.3–38.2)	2.65 (1.87–3.76)	−1.2 (−22.1 to 13.5)
Health behaviors	2.07 (1.42–3.02)	17.7 (−1.2 to 38.4)	2.30 (1.61–3.27)	20.2 (−2.4 to 36.2)
Clinical risk factors	2.04 (1.40–2.97)	20.0 (2.8–37.4)	2.58 (1.82–3.66)	3.1 (−20.9 to 17.5)
Psychosocial factors	1.99 (1.35–2.94)	23.8 (−3.4 to 49.2)	2.50 (1.74–3.60)	8.0 (−21.3 to 26.8)
Family history	2.29 (1.59–3.32)	0.8 (−2.8 to 2.3)	2.66 (1.89–3.75)	−1.8 (−12.6 to 2.5)
All factors	1.42 (0.93–2.17)	67.7 (33.0–112.1)	2.21 (1.47–3.33)	25.8 (−30.9 to 62.5)
Women				
No. of subjects (no. of deaths)	4,405 (55)		848 (122)	
Baseline model	2.50 (1.44–4.36)		2.11 (1.45–3.08)	
Baseline health status	1.98 (1.11–3.55)	34.7 (11.8–67.1)	2.02 (1.37–2.98)	8.1 (−13.5 to 30.4)
Socioeconomic status	2.09 (1.18–3.69)	27.3 (3.8–66.3)	2.15 (1.47–3.15)	−3.6 (−22.4 to 13.6)
Health behaviors	2.28 (1.30–3.99)	14.7 (−3.7 to 37.2)	2.06 (1.40–3.03)	4.5 (−23.2 to 27.4)
Clinical risk factors	2.26 (1.29–3.97)	16.0 (−7.2 to 41.6)	2.11 (1.44–3.11)	0.0 (−29.3 to 19.6)
Psychosocial factors	2.31 (1.27–4.17)	12.7 (−30.3 to 54.3)	2.13 (1.42–3.20)	−1.8 (−48.1 to 21.4)
Family history	2.49 (1.43–4.34)	0.7 (−4.3 to 6.1)	2.12 (1.45–3.09)	−0.9 (−9.4 to 5.6)
All factors	1.36 (0.71–2.62)	76.0 (20.9–145.5)	2.05 (1.33–3.15)	5.4 (−70.2 to 53.4)

Roles of baseline health status, socioeconomic status, health behaviors, clinical risk factors, psychosocial factors, and family history

[a] Percent change in relative hazard was calculated by 100 × $[RH_{\text{baseline model}} - RH_{\text{explanatory variables}}]/[RH_{\text{baseline model}} - 1]$. Baseline model refers to the model adjusted for survey year and age. Bootstrapping methods (1,000 bootstrap samples) were used to estimate the 95% CIs for the percent change

counterparts (Goldman et al. 1995; Johnson et al. 2000). Based on our findings, SRH in younger age groups may well reflect these health-related factors which were strongly associated with all-cause mortality.

However, among older age groups, SRH may mean more than these factors. Since in this study we examined baseline health status, socioeconomic status, health behaviors, clinical risk factors, psychosocial factors, and family history as explanatory variables, other health-related components except for these six factors can be a candidate for the age difference in explanatory abilities. Considering the possible explanations for SRH–mortality association given by Idler and Benyamini (1997), one potential explanation for this age difference in explanatory ability might be that older people may better realize the trajectory of their health conditions. Most deaths especially among elders need to be understood as the end result of cumulative, rather than cross-sectional, exposures of various risk factors across life course (Kuh and Ben-Shlomo 2004). SRH among elders may reflect dynamic, rather than static, perspective on health and thus older people may report their own health based on their judgment on decline (or improvement) in various aspects of health during their life course (Idler and Benyamini 1997). Functional and nutritional status may be important for older people in this judgment. Another potential explanation would be that the presence of certain factors above a certain age cannot discriminate between groups in good and bad SRH. Crude categorization of a continuous health risk (e.g., hypertension, diabetes, etc.) and ignorance of its severity may have resulted in reduced explanatory abilities. Thus, the degree or intensity of a phenomenon (e.g., baseline health status, clinical risk factor) needs to be considered in older age groups.

Results of this study also revealed different levels of percent changes in RH made by health behaviors among elderly men and elderly women. Similar to a previous report (Deeg and Kriegsman 2003), our study indicates the importance of health behaviors among elderly men in reporting their health status. Psychosocial factors have also been studied as a contributor to explain the SRH–mortality association, with mixed results (Larsson et al. 2002; Mackenbach et al. 2002). Results of our study demonstrated a modest contribution of psychosocial factors to the

SRH–mortality relationship in men aged 30–64. However, the magnitude of contribution was smaller in women aged 30–64 and not meaningful at all among men or women aged 65+, although the prevalence of psychosocial factors were patterned by SRH. In addition, our study examined family history as a factor in explaining the SRH–mortality association, although no effect was found.

This study has limitations. First, the number of deaths was relatively small. Dichotomous categorization of SRH variable was thus inevitable for gender- and age-specific analyses. In addition, there is admittedly a considerable uncertainty in the estimates (RHs and percent changes) considering the wide 95% CIs. Second, although measurements were made with well-designed quality control (Khang and Kim 2005a; Khang et al. 2009; MOHW 1999, 2002), exposure variables were measured at a single point and thus do not represent changes over time necessary for dynamic evaluation of SRH for mortality prediction (Ferraro and Kelley-Moore 2001). In addition, psychosocial factors were based on simple questions and might not be able to capture relevant aspects of psychosocial environments.

In conclusion, this study provides evidence of an SRH–mortality association in a representative South Korean sample. Findings show that a wide range of factors related to health could explain the SRH–mortality association in younger age. However, a large part of the mortality differentials by SRH remained unexplained among elderly samples. Research efforts to identify factors in explaining a large part of mortality differentials by SRH are needed especially among older population.

Acknowledgments We thank Sung-Cheol Yun, PhD, in Division of Biostatistics, Center for Medical Research and Information and Department of Preventive Medicine, University of Ulsan College of Medicine, Seoul, Korea, for valuable statistical advice.

Conflict of interest statement We have no conflicts of interest to disclose.

References

Bath PA (2003) Differences between older men and women in the self-rated health-mortality relationship. Gerontologist 43:387–395

Benjamins MR, Hummer RA, Eberstein IW, Nam CB (2004) Self-reported health and adult mortality risk: an analysis of cause-specific mortality. Soc Sci Med 59:1297–1306

Benyamini Y, Idler EL (1999) Community studies reporting association between self-rated health and mortality. Res Aging 21:392–401

Berkman LF, Glass T (2000) Social integration, social networks, social support, and health. In: Berkman LF, Kawachi I (eds) Social epidemiology. Oxford University Press, New York, pp 137–173

Calasanti TM, Slevin KF (2001) Gender, social inequalities, and aging. AltaMira Press, Walnet Creek, CA

Danielsson M, Lindberg G (2001) Differences between men's and women's health: the old and the new gender paradox. In: Ostlin P, Danielsson M, Diderichsen F, Harenstam A, Lindberg G (eds) Gender inequalities in health. A Swedish perspective. Harvard Center for Population and Development Studies, Boston, pp 23–66

Davey B (1995) Birth to old age: health in transition. Open University Press, Oxford

Deeg DJH, Bath PA (2003) Self-rated health, gender, and mortality in older persons: introduction to a special section. Gerontologist 43:369–371

Deeg DJH, Kriegsman DMW (2003) Concepts of self-rated health: specifying the gender difference in mortality risk. Gerontologist 43:376–386

Ferraro KF, Kelley-Moore JA (2001) Self-rated health and mortality among black and white adults: examining the dynamic evaluation thesis. J Gerontol Soc Sci 56:195–205

Goldman N, Korenman S, Weinstein R (1995) Marital status and health among the elderly. Soc Sci Med 40:1717–1730

Heidrich J, Liese AD, Lowel H, Keil U (2002) Self-rated health, its relation to all-cause, cardiovascular mortality in southern Germany. Results from the MONICA Augsburg cohort study 1984–1995. Ann Epidemiol 12:338–345

Heistaro S, Jousilahti P, Lahelma E, Vartiainen E, Puska P (2001) Self rated health and mortality: a long term prospective study in eastern Finland. J Epidemiol Community Health 55:227–232

Huisman M, Kunst AE, Bopp M et al (2005) Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. Lancet 365:493–500

Idler EL, Benyamini Y (1997) Self-rated health and mortality: a review of twenty-seven community studies. J Health Soc Behav 38:21–37

Idler EL, Russell LB, Davis D (2000) Survival, functional limitations, self-rated health in the NHANES I Epidemiologic Follow-up Study, 1992. First National Health and Nutrition Examination Survey. Am J Epidemiol 152:874–883

Jee SH, Ohrr HC, Kim IS (1994) Self rated health and mortality in elderly. Kangwha cohort, 8-year follow up. Kor J Epidemiol 16:172–180

Johnson NJ, Backlund E, Sorlie PD, Loveless CA (2000) Marital status and mortality: the National Longitudinal Mortality Study. Ann Epidemiol 10:224–238

Kaplan GA, Goldberg DE, Everson SA et al (1996) Perceived health status and morbidity and mortality: evidence from the Kuopio ischaemic heart disease risk factor study. Int J Epidemiol 25:259–265

Khang YH, Kim HR (2005a) Explaining socioeconomic inequality in mortality among South Koreans: an examination of multiple pathways in a nationally representative longitudinal study. Int J Epidemiol 34:630–637

Khang YH, Kim HR (2005b) Relationship of education, occupation, and income with mortality in a representative longitudinal study of South Korea. Eur J Epidemiol 20:217–220

Khang YH, Lynch JW, Kaplan GA (2004) Health inequalities in Korea: age- and sex-specific educational differences in the 10 leading causes of death. Int J Epidemiol 33:299–308

Khang YH, Lynch JW, Jung-Choi KH, Cho HJ (2008) Explaining age specific inequalities in mortality from all causes, cardiovascular disease and ischaemic heart disease among South Korean male public servants: relative and absolute perspectives. Heart 94:75–82

Khang YH, Lynch JW, Harper S, Yang S, Jung-Choi K, Kim HR (2009) Material, psychosocial, and behavioral factors to explain educational and occupational mortality inequalities in a nationally representative sample of South Korea: relative and absolute perspectives. Soc Sci Med 68:858–866

Kuh D, Ben-Shlomo Y (2004) A life course approach to chronic disease epidemiology, 2nd edn. Oxford University Press, New York

Larsson D, Hemmingsson T, Allebeck P, Lundberg I (2002) Self-rated health and mortality among young men: what is the relation and how may it be explained? Scand J Public Health 30:259–266

Mackenbach JP, Simon JG, Looman CWN, Joung IMA (2002) Self-assessed health and mortality: could psychosocial factors explain the association? Int J Epidemiol 31:1162–1168

McCallum J, Shadbolt B, Wang D (1994) Self-rated health and survival: a 7-year follow-up study of Australian elderly. Am J Public Health 84:1100–1105

MOHW (Ministry of Health and Welfare of Korea) (1999) Interim report on the 1998 National Health and Examination Nutrition Survey. Ministry of Health and Welfare of Korea, Kwachon, Korea

MOHW (Ministry of Health and Welfare of Korea) (2002) Interim report on the 2001 National Health and Examination Nutrition Survey. Ministry of Health and Welfare of Korea, Kwachon, Korea

Pijls LT, Feskens EJ, Kromhout D (1993) Self-rated health, mortality, chronic diseases in elderly men. The Zutphen Study, 1985–1990. Am J Epidemiol 138:840–848

Singh-Manoux A, Martikainen P, Ferrie J, Zins M, Marmot M, Goldberg M (2006) What does self rated health measure? Results from the British Whitehall II and French Gazel cohort studies. J Epidemiol Community Health 60:364–372

Svedberg P, Bardage C, Sandin S, Pedersen NL (2006) A prospective study of health, life-style and psychosocial predictors of self-rated health. Eur J Epidemiol 21:767–776

WHO Expert Consultation (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 363:157–163