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ORIGINAL ARTICLE

The impact of changes in self-rated general health on 28-year mortality among middle-aged Danes

ANNI BRIT STERNHAGEN NIELSEN[1], VOLKERT SIERSMA[2], SVEND KREINER[2], LINE CONRADSEN HIORT[2], THOMAS DRIVSHOLM[1,3], LENE FALGAARD EPLOV[3] & HANNE HOLLNAGEL[1,3]

[1]*The Research Unit and Department of General Practice, University of Copenhagen,* [2]*Department of Biostatistics, Institute of Public Health, University of Copenhagen,* [3]*Copenhagen County Research Centre for Prevention and Health, Glostrup University Hospital, Copenhagen, Denmark*

Abstract

Objective. Self-rated general health (SRH) predicts future mortality. SRH may change, and these changes may alter the mortality risk. All-cause mortality until the age of 68 and its association with changes in SRH from the age of 40–45, 45–51, and 51–60 years was examined in a cohort of Danes. *Design.* Prospective population study started in 1976 with follow-up in 1981, 1987, and 1996. *Setting.* Suburban area of Copenhagen. *Subjects.* A total of 1198 individuals born in 1936. *Main outcome measure.* All-cause mortality. *Results.* Among participants with two consecutive SRH ratings the mortality rate per 1000 observation years was 7.6 (95% CI 6.4; 8.9), 8.5 (95% CI 7.1; 10.2), and 8.9 (95% CI 6.4; 10.3) after the 45-, 51-, and 60-year examination. Decline in SRH between two time-points was in bivariate Cox regression analyses associated with an increased mortality risk, the association increasing as participants grew older. Multivariate analysis of the effect of changes of SRH on mortality gave similar results: hazard ratios for declined SRH were (reference: "unchanged good") 1.55 (95% CI 0.93–2.58), 1.96 (95% CI 1.09–3.53), and 2.22 (95% CI 0.97–5.09) at the 40–45, 45–51, and 51–60-year intervals. However, unchanged poor and improved SRH (at the 40–45-year interval) were also associated with an increase, and additional analyses showed that just rating SRH as poor at one rating was associated with increased risk. *Conclusion.* Changes in SRH are associated with higher mortality risks than unchanged good SRH.

Key Words: *Cohort studies, Denmark, health status, longitudinal studies mortality, self-rated health*

General practitioners' (GPs') and patients' evaluation of the patient's health may differ [1–3]. Patients' own health perception, measured by a single question, known as self-rated general health (SRH), may extend objective information. SRH has been shown to predict future morbidity like ischaemic heart disease [4] and future mortality independently of risk factors of future morbidity and mortality, e.g. smoking, low physical activity, age, sex, and socioeconomic status [5,6].

Several community-based studies with a follow-up of 2–28 years have demonstrated that the worse SRH is at baseline, the greater risk of future mortality [6]. However, people may change their SRH over time [7,8], and this may alter the mortality risk.

Few studies have examined change in SRH and its association with mortality [8–13]. In some, "unchanged poor" [12] or "declined" [9,11–13] SRH was associated with increased mortality risk, but in others "unchanged poor" [9] or "declined" SRH [8,10] had only a weak or no association with mortality risk. Only a few studies included a population-based sample [8,10], younger persons [8,10], a long follow-up [8,10,12], and not many performed multivariate analysis [8,10,12,13]. Accordingly, there is a need for further research into

Correspondence: Anni B.S. Nielsen, The Research Unit for General Practice in Copenhagen, Centre for Health and Society, University of Copenhagen, Øster Farimagsgade 5, PO box 2099, DK-1014 Copenhagen K; Denmark. E-mail: a.nielsen@gpract.ku.dk

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The single-item question of self-rated general health is an independent predictor of future morbidity and mortality risk.

- Other ratings than unchanged good self-rated general health are associated with increased mortality risk independently of well-known risk factors of future morbidity and mortality.
- The predictive value of self-rated general health indicates that it is important to examine what lies behind self-rated general health.

the relationship between changes in SRH and mortality risk.

This study examines all-cause mortality from 40 to 68 years and its association with changes in SRH from the age of 40–45, 45–51, and 51–60 years in a cohort of Danes.

Material and methods

Study population

The analyses were based on the 1936 cohort at the Copenhagen County Research Centre for Prevention and Health (formerly the Glostrup Population Studies). The study included persons born in 1936, who, on 2 April 1976 were resident in one of four municipalities in suburban Copenhagen (n = 1198) [14–19]. Cohort members' health was examined at the ages of 40, 45, 51, and 60 years. All participants were followed through the Danish register of deaths.

At the 40-year health examination, participation reached 87.8% of 1198 invited. At the 45-year examination, 83.5% of 1188 survivors participated. At the 51-year examination, 83.8% of 1151 survivors participated. At the 60-year examination, 61.1% of 1085 survivors participated. From the 60-year examination until 2004, another 110 persons had died.

The participants at the 40-year examination were regarded as representative of both the cohort and the background population: only diminutive differences existed between participants and non-participants (e.g. no differences in SRH), and between participants and non-cohort citizens [14,20]. Similar conclusions were reached at the 45-year [15] and 51-year [16] examination, but non-participants at the 60-year examination had a worse health profile than participants [20]. Recent analysis documented that non-participants at the three first health examinations had a mortality rate twice as high as that of participating cohort members [20], a well-known finding also shown in other studies.

Outcomes

End-point variables were all-cause death within the period from the first examination day of a participant at the 45-year examination until censoring date, 11 March 2004.

Measurements

Detailed information on methods used at the 40-, 45-, 51-, and 60-year examination has been reported previously [14,17–19,21,22]. At all examinations, data were collected under standardised conditions; however, the methods may vary between examinations and some information may not have been obtained at all health examinations, e.g. no clinical and paraclinical information was gathered among women at the 51-year examination. In brief, the extensive 40-year examination comprised a self-administered questionnaire, an interview-administered questionnaire about psychosocial conditions, and paraclinical examination, e.g. blood samples, ECG, and pulmonary function test [17].

In questionnaires, filled in at home prior to the health examination, participants gave information on their SRH by answering the question: "How would you characterise your own health during the last year?" The response categories were "extremely good", "good", "poor", "miserable". SRH was dichotomised into good, covering "extremely good" or "good" versus poor, covering "poor" or "miserable". Consequently, the change in SRH between two time points was "unchanged good", "unchanged poor", "improved", or "declined".

Statistical analysis

Mortality incidence per 1000 observation years with 95% confidence intervals (CIs) was calculated assuming Poisson distributed event occurrences. The effect of an SRH change was analysed in Cox proportional hazard models in three different analyses: the first started at the date of the 45-year examination and followed the persons until date of death or censoring, and considered the effect of change in SRH between age 40 and 45. The second analysis included persons from the date of their 51-year examination until death or censoring, and considered the effect of change in SRH between age 45 and 51, and did not take SRH at age 40 years into consideration. Similarly, the last analysis started at the date of the 60-year examination and only considered change in SRH since the age of 51. The analyses were repeated with adjustment for

covariates that had demonstrated associations with both SRH and all-cause mortality: sociodemographic characteristics and sex, clinical manifestations, symptoms, absence from work due illness, health-affecting habits, and clinical and biochemical information related to cardiovascular disease measured at the latest health examination and information on chronic illness (see Appendix). Additionally, the adjusted analyses performed were restricted to those participants who were coded as chronically ill, and to those who were coded as not chronically ill at both ratings. A Wald test was used to assess the overall significance of SRH change. Many of the covariates in the multivariate analyses may be in the causal pathway between SRH change and mortality. Hence, the effect estimate of SRH change in the adjusted analyses shows the effect that cannot be explained by the covariates in the causal pathway. To analyse whether just having poor SRH at one age-interval captures the same information as the four classes of the SRH change, a likelihood ratio test of a multivariate model with SRH dichotomised "unchanged good" and a combined "unchanged poor, declined, improved" against the above model with four classes of SRH change was done. Model reduction was performed by eliminating covariates, not SRH, with a significance level of 20% or more from the full model. In all other analyses the level was set to 5%. The category "unchanged good" SRH was used as reference category.

Results

SRH remained relatively stable, as participants grew older (Table I).

Table II shows the relationship between change in SRH and mortality rate per 1000 observation years. The effect of an SRH change on mortality appears more pronounced in the older age groups.

The overall mortality effect of an SRH change was statistically significant at age intervals 40–45 and 51–60, but not at 45–51 years (Table III), even though comparing the "declined" to the "unchanged good" group also suggested an increased mortality risk among the former at age-interval 45–51. A higher mortality risk in the groups "unchanged poor" and "improved" at age-interval 40–45 years is indicated when comparing with the "unchanged good" group: the results were almost similar by inclusion of covariates, although the mortality effect of a SRH change became statistically insignificant at age-interval 51–60 years. Well-known factors only partly explained the association between changed SRH and mortality in the multivariate analyses. In participants with chronic illness at both ratings, unchanged poor SRH increased risk at all age intervals. Among participants without chronic illness, "declined" SRH was associated with increased and "unchanged poor" with decreased risk. However, only few participants were included in these additional analyses.

Models where an indication of having poor SRH at one or both of the ratings enters instead of the four classes of SRH change were not significantly worse than the model with four classes of SRH change ($p = 0.60$, $p = 0.65$, $p = 0.057$), at the 40–45, 45–51, and 51–60-year intervals. The corresponding adjusted hazard ratios (HRs) for having unchanged good vs. not having unchanged good SRH were 1.85 (95% CI 1.31–2.62), 1.61 (95% CI 1.05–2.47), and 1.20 (95% CI 0.50–2.85).

Discussion

Principal findings

The main finding of this follow-up study on the relationship between change in SRH at age intervals 40–45, 45–51, and 51–60 years and all-cause mortality until the age of 68 was a trend-like relationship between a decrease in SRH and mortality risk,

Table I. Percentage of respondents who changed their self-rated general health between two consecutive health examinations at the age of 40–45, 45–51, and 51–60 years.

	Age at each health examination (years)		
	40 and 45	45 and 51	51 and 60
Women			
n	501	474	352
% who improved in SRH[1]	7.8	8.6	8.0
% who declined in SRH[1]	11.2	8.9	11.9
% with unchanged poor SRH[1]	10.2	13.1	12.2
% with unchanged good SRH[1]	70.9	69.4	67.9
Men			
n	458	417	310
% who improved in SRH[1]	5.9	6.0	3.5
% who declined in SRH[1]	7.9	6.2	10.0
% with unchanged poor SRH[1]	3.5	4.6	4.5
% with unchanged good SRH[1]	82.8	83.2	81.9
Total			
n	959	891	662
% who improved in SRH[1]	6.9	7.4	5.9
% who declined in SRH[1]	9.6	7.6	11.0
% with unchanged poor SRH[1]	7.0	9.1	8.6
% with unchanged good SRH[1]	76.5	75.9	74.5

Notes: [1]The measure of self-rated general health (SRH) was dichotomised into poor (covers "poor" and "miserable") and good (covers "extremely good" and "good").

Table II. Self-rated general health at two consecutive health examinations and mortality rate per 1000 observation years until date of censoring due to mortality (23 years follow-up): Bivariate analysis.

	Age at each health examination (years)								
	40 and 45			45 and 51			51 and 60		
	Change in SRH[1]	Died after the age of 45		Change in SRH[1]	Died after the age of 51		Change in SRH[1]	Died after the age of 60	
	n	D[2]	Mortality rate[3] (95% CI)[5]	n	D[2]	Mortality rate[3] (95% CI)[5]	n	D[2]	Mortality rate[3] (95% CI)[5]
SRH[4]									
Improved	66	19	14.2 (8.6; 22.2)	66	9	8.8 (4.0; 16.7)	39	1	3.6 (0.1; 19.8)
Declined	92	18	9.8 (5.8; 15.5)	68	14	13.8 (7.6; 23.2)	73	10	20.7 (9.9; 38.0)
Unchanged poor	67	17	12.8 (7.5; 20.5)	81	14	11.1 (6.1; 18.6)	57	6	15.3 (5.6; 33.4)
Unchanged good	734	98	6.3 (5.1; 7.7)	676	82	7.7 (6.1; 9.5)	493	24	6.9 (4.4; 10.3)
Total N%	959	152	7.6 (6.4; 8.9)	891	119	8.5 (7.1; 10.2)	662	41	8.9 (6.4; 12.1)

Notes: [1]Self-rated general health (SRH). D[2] Number of deaths. [3]Until date of censoring per 1000 observation years. [4]The measure of self-rated general health was dichotomised into poor (covers "poor" and "miserable") and good (covers "extremely good" and "good").[5]The 95% confidence interval (CI).

demonstrated by increased HRs, as participants grew older. Additional analyses showed, however, that having poor SRH at one of the two ratings might describe the risk increase just as well as a model with four classes of SRH change.

Study strengths and weaknesses

The strengths of this study are the data from a population-based sample on a relatively young cohort, the detailed subjective and objective information gathered four times on participants, and the long follow-up time with 100% follow-up on all-cause mortality.

A potential weakness was lack of information on other comorbidities, e.g. cancer, which may have a direct influence on the participants' SRH, change in SRH, and mortality. However, we accounted for chronic illness and work absence. Furthermore, our cohort was relatively young, and we included risk factors of future morbidity associated with high mortality rates (BMI, serum insulin, fasting plasma glucose, serum cholesterol, and BP).

Non-participants had a higher mortality than participants. However, this may not necessarily affect our estimates of the association between SRH changes and mortality. Some analyses omitted information because of missing values. This may render the influence of SRH more pronounced that it actually is.

Baseline analyses of participants in the 40-year examination showed that worse SRH was associated with increased GP and hospital use [23]. A Danish follow-up study also confirms that moderate/worse SRH predicts GP utilisation and hospitalisation [24]. Healthcare utilisation is, however, beyond this article's scope. Furthermore, we have no information on the GPs' advice to the patients. How GP advice may affect the patients' SRH calls for new research.

Relation to other studies

Our finding that decreased SRH tends to be associated with increased mortality risk tallies with the results of studies among elderly people [9–12]. However, the relationship between (changes in) SRH and mortality risk among younger persons has not previously been examined, and our results may indicate that elderly persons may better sense if they are about to become ill/die. In a Swedish study a health decline among 60- to 67-year-old men increased the mortality risk [9]; a similar result was found in a 12-year follow-up study of elderly Swedish twins [12]: those with "declined" SRH after six years were more likely to die than those with "unchanged good" SRH. A cohort study on SRH patterns before significant medical events among elderly Americans, followed half-yearly for eight years, demonstrated that SRH gradually decreased five years preceding death [11]. Another American study reached a similar conclusion for African-Americans, with follow-up after 10, 15, and 20 years. However, among Caucasians only baseline SRH was associated with mortality risk [10].

"Unchanged poor" compared with "unchanged good" SRH has a relatively stable relation to

Table III. Cox regression analysis until date of censoring due to mortality (23 years follow-up) estimated by changed self-rated general health at age-intervals 40–45, 45–51, and 51–60 years of participants in a health survey.

	Age at each health examination (years)					
	40 and 45		45 and 51		51 and 60	
	Hazard ratio (95% CI)	p[2]	Hazard ratio (95% CI)	p[2]	Hazard ratio (95% CI)	p[2]
All participants, n	152		119		41	
			Analysis without inclusion of covariates			
SRH[1]		0.0008		0.15		0.01
Improved	2.30 (1.41; 3.76)		1.15 (0.58; 2.28)		0.51 (0.07; 3.78)	
Declined	1.56 (0.94; 2.58)		1.82 (1.03; 3.21)		3.01 (1.44; 6.29)	
Unchanged poor	2.04 (1.22; 3.41)		1.44 (0.82; 2.54)		2.21 (0.90; 5.40)	
Unchanged good	1		1		1	
All participants[3]			Analysis with inclusion of covariates			
SRH [1]		0.004		0.12		0.14
Improved	2.12 (1.27; 3.52)		1.35 (0.67; 2.72)		0.54 (0.07; 4.02)	
Declined	1.55 (0.93; 2.58)		1.96 (1.09; 3.53)		2.22 (0.97; 5.09)	
Unchanged poor	2.02 (1.19; 3.41)		1.52 (0.82; 2.84)		2.07 (0.78; 5.46)	
Unchanged good	1		1		1	
Only participants who at both age intervals had chronic illness[3]			Analysis with inclusion of covariates			
n	43		37		22	
SRH[1]		0.007		0.21		0.64
Improved	2.24 (1.01; 4.96)		1.04 (0.31; 3.49)		–	
Declined	0.83 (0.23; 2.90)		1.97 (0.65; 5.95)		0.69 (0.14; 3.42)	
Unchanged poor	4.38 (1.71; 11.22)		2.41 (1.02; 5.69)		1.86 (0.56; 6.20)	
Unchanged good	1		1		1	
Only participants who at both age intervals had no chronic illnesss[3]			Analysis with inclusion of covariates			
n	102		61		16	
SRH[1]		0.04		0.77		0.13
Improved	1.92 (0.92; 4.01)		1.17 (0.46; 3.02)		2.08 (0.27; 16.10)	
Declined	2.05 (1.14; 3.68)		1.48 (0.60; 3.66)		4.00 (1.27; 12.59)	
Unchanged poor	0.76 (0.23; 1.44)		0.85 (0.30; 2.45)		–	
Unchanged good	1		1		1	

Notes: [1]Self-rated general health (SRH). The measure of SRH was dichotomised into poor (covers "poor" and "miserable") and good (covers "extremely good" and "good"). [2]P-value of a Wald test for the overall effect of the changes in SRH on mortality. "Pairwise" analysis is to compare the "unchanged good" category with another category within an age-category (i.e. 40–45 years), i.e. by using the 95% CI. [3]Analysis with inclusion of covariates with p-value below 0.2 in full model (see appendix).

mortality in the analyses including all participants throughout all adjusted analyses of change of SRH (HR = 2.02, HR = 1.52, and HR = 2.07 at age-intervals 40–45, 51–60, and 45–51 years, respectively). Similar results were obtained among participants with chronic illness, although HR was larger. Among participants without chronic illness, "unchanged poor" indicated a decreased risk at all age-intervals although having declined or improved SRH gave a relatively high risk. Only two studies, including elderly persons, have reported on the relationship (not stratified for chronic illness) between "unchanged poor" SRH and mortality: one found an unchanged [9], the other an increased mortality risk [12]. Generally, "unchanged poor" SRH carries an increased mortality risk, but the group who rate their health as poor may comprise both health pessimists and persons with actual "poor" health [25], which is illustrated by the analysis among those without and with chronic illness. The increased risk among participants without chronic illness who improved or declined in SRH tallies with the results of Idler et al. [26], who found that healthy Americans participating in a population survey who rated their health poor or fair as compared with excellent had an increased mortality risk.

Improved SRH at the age-interval 40–45 gave a higher mortality risk (HR = 2.12) than "declined" SRH as compared with unchanged good SRH. The effect of change in SRH in the age interval 40–45 appears therefore not to be associated with deterioration of health in general. No other researchers have reported such results. Our additional analyses showed that it is presumably rather a question of whether or not SRH has been poor at some point during the interval in question.

Several hypotheses exist on the relationship between SRH and an augmented mortality risk. One suggests that an SRH decrease captures information on future health not reflected in the actual objective health status [10], e.g. due to preclinical illness, and that it reflects family history [6].

Implications

The relationship between unchanged good SRH and decreased mortality risk supports the research which shows that SRH is a predictor of mortality. Since knowledge of the relationship between SRH changes and future mortality derives mainly from studies including older participants, we suggest that future studies focus on changed SRH among younger persons, examine whether just having had poor SRH during a period is a predictor of mortality, and whether SRH ratings among those with and without chronic illness give similar information.

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Appendix: Possible covariates of the association between future mortality and changes in self-rated general health at age-intervals 40–45 years, 45–51 years, and 51–60 years

The following covariates were included in the final multivariate models (see Table III):

- 40 to 45 years: Sex, co-habiting status, social status, abdominal pain, chronic bronchitis, present tiredness, smoking habits, leisure-time physical activity, alcohol consumption, work absence for more than one week, cholesterol, systolic BP, BMI, and interaction between chronic illness at 40 years (yes/no) and chronic illness at 45 years (yes/no) were included in the final model. *Fasting plasma glucose and insulin were excluded from the multivariate model since 47 participants had missing plasma glucose values due to technical failure, and all participants in the 45-year examination had no measurement of insulin.*
- 45 to 51 years: Sex, co-habiting status, social status, abdominal pain, chronic bronchitis, present tiredness, smoking habits, leisure-time physical activity, alcohol consumption, work absence for more than one week, BMI, and interaction between chronic illness at 45 years (yes/no) and chronic illness at 51 years (yes/no) were included in the final model. *Fasting plasma glucose, cholesterol, insulin, and systolic BT were excluded from the multivariate model due to missing values among all women.*
- 51 to 60 years: Sex, co-habiting status, social status, abdominal pain, chronic bronchitis, present tiredness, smoking habits, leisure-time physical activity, alcohol consumption, cholesterol, insulin, fasting plasma glucose, systolic BP, BMI, and interaction between chronic illness at 51 years (yes/no) and chronic illness at 60 years (yes/no) were included in the final model. W*ork absence was omitted from the multivariate model because values were missing for nine participants.*

Division of the included covariates:

- Sex$^{\star\text{¤}}$
- Co-habiting status (single/cohabiting)$^{\star\text{¤}}$
- Social status, determined on the basis of a method developed by the Danish National Institute of Social Research. Three criteria were used: occupation, education, and number of subordinates (I–II, III, IV,V. I–II = highest vs. V = lowest social status)$^{\#\text{¤}}$
- Leisure-time physical activity (fully sedentary vs. at least four hours per week of walking, bicycling, or other activity/some fitness sports training or other strenuous activities for at least three hours per week/regular competitive sports)*
- Smoking habits (never vs. previous/ present smoker)*
- Alcohol consumption, where the unit of measurement constituted the number of drinks per week, continuous variable
- Work absence for more than one week within past year (yes/no)*
- Four questions concerning epigastric pain and indigestion combined into an index covering abdominal pain (yes/no)*
- Six questions concerning coughing and expectoration, including length, combined into an index covering chronic bronchitis (yes/no)*
- Present tiredness (yes/no)*
- Casual systolic blood pressure, mmHg, measured in sitting position in accordance with WHO recommendations, continuous variable*†
- Body mass index, calculated as body weight (kg) divided by the height squared (m^2), continuous variable*
- Serum insulin, pmol/l, continuous variable$^{\partial\diamond\dagger}$

- Fasting plasma glucose, mmol/l, continuous variable[§∂◇†]
- Serum cholesterol, mmol/l, continuous variable[§∂◇†]
- Chronic illness[1] at two consecutive SRH ratings (two variables: previous and present SRH rating. Both variables coded no/yes) based on information on "yes" to one or more of the questions below:
  - Presence of angina pectoris[#]
  - Chronic illness (diagnosed by Hanne Hollnagel at the clinical examination)[#]
  - Has a doctor told you that you have...
    - diabetes?[⋆]
    - an inherited heart disease?[⋆]
    - hypertension?[⋆]
    - a thrombosis in the heart?[⋆]
  - Daily or weekly use of diuretics or anti hypertensive medication[⋆]

Explanation.

⋆	Measured at all health examinations (the ages of 45, 51, and 60 years)
#	Measured at the age of 40 years
§	Measured at the age of 45 years
∂	Measured at the age of 51 years
◇	Measured at the age of 60 years
¤	The information was included as baseline information in all statistical analyses
†	Not obtained among women at the 51-year examination

[1]Chronic illness was used to divide patients into a group with and without chronic illness at the two consecutive SRH ratings.