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Lifecourse correlates of self-rated health and associations with subsequent mortality: findings from the Hertfordshire Cohort Study

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ABSTRACT

Background: Poor self-rated health (SRH) has been shown to predict adverse health outcomes among older people, however these associations have traditionally only been considered at one point in the lifecourse, usually midlife or later. Here we examined lifecourse correlates of SRH in early, mid and later life, relating these to subsequent risk of mortality in a community-dwelling cohort.

Methods: 2989 men and women from the Hertfordshire Cohort Study (HCS) were included in this study. The HCS was initially retrospective and linked contemporary health outcome data to early life data available from health ledgers but investigations from baseline (1998–2004, aged 59–73) onwards have been prospective. At baseline, participants completed an initial clinic visit, which included questionnaire assessment of SRH, reported as 'excellent', 'very good', 'good', 'fair', or 'poor'. Socioeconomic, lifestyle, mental health and demographic information was also collected. Deaths were recorded from baseline to 31/12/2018. Baseline characteristics in relation to SRH were examined using sex-stratified ordinal logistic regression; these factors were examined in relation to mortality using sex-stratified Cox regression. Statistically significant exposures were then included in sex-stratified mutually-adjusted models.

Results: In mutually-adjusted analysis, numerous contemporaneous correlates of poorer SRH in the seventh decade were identified and included obesity, lower physical activity, greater comorbidity and higher levels of depression among men and women. For example, odds ratios for being in a lower category of SRH were as follows: obese (BMI≥30) vs underweight/healthy (BMI<25) (men 1.60 (1.21, 2.11), women 1.65 (1.25, 2.17)) and per additional system medicated (men 1.62 (1.47, 1.77), women 1.53 (1.41, 1.66)). By contrast, factors earlier in the lifecourse (early growth, age left full-time education) were not associated with SRH in late adulthood. 36% of men and 26% of women died during follow-up. Hazard ratios (95% CI) for mortality per lower category of SRH were 1.22 (1.10,1.36) among men and 1.17 (1.01,1.35) among women after adjustment for age, BMI, smoking, physical activity, diet quality, education, home ownership status, comorbidity level and depression levels, suggesting residual confounding by other unrecorded factors that are related to SRH.

Conclusions: Poorer SRH in the seventh decade was a risk factor for mortality. Importantly modifiable adverse health behaviours in the seventh decade, such as low physical activity, were associated with poorer SRH and later mortality after adjustment for socioeconomic factors and comorbidity level. By contrast early growth and education were not related to later SRH. These data suggest that attention to lifestyle in late midlife may be

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associated with better SRH and subsequent health outcomes, highlighting the value of intervention at this stage of the lifecourse.

1. Introduction

Self-rated health (SRH) is a health measure based upon a simple question asking individuals to rate their general health using a four or five-point scale [1]. It has been shown to be an important health predictor of future healthcare utilization, mortality and quality of life [1–3]. It has been widely used in both population-based and clinical studies to assess future adverse health outcomes, and may also provide a good screening tool for general health assessment in general practice [2,4].

Available literature from several studies includes discussion of the sociodemographic, disease-related, and lifestyle determinants of SRH [2,5]. In general, women, individuals with lower socioeconomic status, and older individuals tend to report lower SRH ratings, although some studies have suggested that sexual dimorphism exists [6–8]. Furthermore, disease-related factors (such as co-existence of diseases, medication usage, hospitalization and utilization of health care services) are also associated with SRH, especially in older populations [5,9,10]. Findings regarding associations between SRH and lifestyle factors vary among studies and populations, but they consistently point towards a common trend: individuals who adopt a more proactive lifestyle tend to rate their health more positively [5,11].

To the best of our knowledge however, despite several recent studies that consider determinants of SRH [12–15], these all typically report associations in individuals at a single point in the lifecourse. The Hertfordshire Cohort Study is a unique national resource that has curated detailed information on individuals in their seventh decade, for whom information on early life factors is also available. This allows us to consider what factors across the lifecourse are associated with SRH later in life. This information is important to policy makers and health care providers as it might allow us to identify factors with the strongest associations that might be targeted in public health interventions given the aforementioned relationships between SRH and health care utilization and outcomes. We were particularly interested to study this issue in this cohort as the developmental origins of health and disease hypothesis suggests that early life factors, such as birthweight and infant growth, might influence an individual's health status in later life, and their susceptibility to diseases [16]. Therefore, it is plausible that factors throughout the life span, including early life, may be linked to SRH during older age.

In this study we have considered relationships between each of the following participant characteristics and SRH: birthweight, weight at one year, age when leaving education, social class and home ownership, lifestyle factors in adulthood including smoking history, obesity, and medical history (assessed as comorbidity burden at the time of SRH assessment). We also considered relationships between SRH and subsequent mortality over 20 years of follow-up in the cohort, before and after adjustment for these factors.

2. Methods

2.1. The Hertfordshire Cohort Study

The Hertfordshire Cohort Study (HCS) is a study of 2997 men and women who were born in Hertfordshire (UK) between 1931 and 1939 and still lived there in 1998–2004 [17]. Information on their early life, including birthweight and weight at one year was available from birth ledgers. In 1998–2004, they completed a home interview and attended a clinic for a health assessment. The HCS received ethical approval from the Hertfordshire and Bedfordshire Local Research Ethics Committee, and all participants gave written informed consent for the assessments they had at the clinic and for researchers to access their medical records in the future. More detailed information about the HCS has been published regarding these clinic visits, but are summarized below [17-19].

2.2. Ascertainment of early life characteristics

Midwives recorded birthweights in ledgers, as reported previously [17]. At one year of age, the babies were weighed by health visitors. These measurements were recorded in pounds and ounces and converted to kilograms. Conditional infant weight gain, a measure of infant growth which is independent of birthweight, was derived separately for males and females, as previously described [20]. The age at which participants left full-time education was ascertained during the home interview (1998–2004).

2.3. Ascertainment of later life characteristics

During home interviews (1998–2004), researchers collected information on participants' smoking status (never smoker, previous smoker, or current smoker), weekly alcohol intake, and physical activity levels [21]. Participants also filled out a food-frequency questionnaire, which was used to calculate a 'prudent diet' score through principal components analysis; a higher score indicated a healthier diet. Occupational social class of participants was determined based on their most recent or current full-time job for men and unmarried women, and on the husband's job for married women. These occupations were then categorized according to the 1990 OPCS Standard Occupational Classification (SOC90) unit group for occupation [22]. Additional data collected also included housing tenure (owned/mortgaged or rented/other). Participants also rated their general health using the SF-36 Health Survey, choosing from 'Excellent', 'Very good', 'Good', 'Fair', or 'Poor'[23]. Information on all over-the-counter and prescription medications currently taken by the participants was recorded. These were coded according to the British National Formulary, and the number of systems medicated was calculated and used as an indicator of comorbidity level. Anxiety and depression were ascertained using the Hospital Anxiety and Depression Scale. At the baseline clinic, height was measured (Harpenden pocket stadiometer, Chasmors Ltd, London, UK) along with weight (SECA floor scale, Chasmors Ltd, London, UK). These measurements were used to derive BMI (kg/m^2) which was categorised initially as underweight (<18.5), healthy (18.5–24.9), overweight (25–29.9), obese (30–39.9), and severely obese (≥40); for analysis of associations, the categories underweight / healthy (<25), overweight (25–29.9) and obese (≥30) were used to avoid sparse categories.

2.4. Ascertainment of mortality events

Permission to obtain mortality data from HCS participants and to link this information with cohort data was provided by NHS Digital and the Ethics and Confidentiality Committee of the National Information Governance Board. Deaths from baseline (1998–2004) until 31st December 2018 were analysed.

2.5. Statistical methods: use of logistic and Cox regression to examine associations

Participant characteristics were described using summary statistics. Early life exposures included birthweight, weight at one year, conditional infant weight gain, and age left full-time education (before age 15 versus at least 15); baseline exposures included age, height, categorised BMI (underweight / healthy (<25), overweight (25–29.9) and obese (≥30)), ever smoking, high alcohol intake (units per week: >21 men,

>14 women), physical activity, diet quality, manual occupational social class, home ownership status (not owning one's home vs owning one's home), number of systems medicated, anxiety scores and depression scores. All exposures were treated as continuous unless stated otherwise. Early life and baseline characteristics in relation to SRH were examined using univariate ordinal logistic regression. These characteristics, along with SRH, were examined in relation to all-cause mortality using univariate Cox regression. In each analysis, statistically significant correlates were then included in mutually-adjusted models. Sensitivity analyses were also performed which repeated the analysis for all-cause mortality using the following outcomes: cardiovascular-related mortality (ICD-10 codes: I10-I79) and cancer-related mortality (ICD-10 codes: C00-C97). Sex-specific standard deviation scores (z-scores) were derived for continuous exposures. Analyses were stratified by sex; $p<0.05$ was regarded as statistically significant. Analyses were conducted using Stata, release 17.0.

3. Results

3.1. Participant characteristics

Participant characteristics of the analysis sample are described in Table 1. Mean (SD) age at baseline was 66.1 (2.8) years. Overall, 11% of men and 15% of women had fair/poor SRH; 36% of men and 26% of women died during follow-up.

3.2. Associations between participant characteristics and SRH

Odds ratios for being in a worse category of SRH according to each participant characteristic are presented in Table 2. Among men and women, the following characteristics were associated ($p<0.05$) with poorer SRH in unadjusted analysis: overweight or obese compared to underweight/healthy; ever smoking; lower physical activity; poorer diet quality; manual social class; not owner-occupying one's home; greater numbers of systems medicated; higher anxiety scores; and higher depression scores. The following characteristics remained significant in mutually-adjusted analysis: obesity; physical activity; diet quality (women); home ownership (men); number of systems medicated; anxiety scores (women); and depression scores. Shorter height was associated with poorer SRH among women in both unadjusted and mutually-adjusted analysis. Birthweight and conditional infant weight gain were not associated with SRH among either sex.

Table 1
Participant characteristics of the analysis sample.

Participant characteristic [mean (SD), median (lower quartile, upper quartile), or %]	Men (n=1577)	Women (n=1412)
Early life characteristics		
Birthweight (kg)	3.5 (0.5)	3.3 (0.5)
Weight at age one year (kg)	10.2 (1.1)	9.7 (1.0)
Left school before age 15	19%	17%
Characteristics at baseline (1998–2004)		
Age (years)	65.7 (2.9)	66.6 (2.7)
Height (cm)	174.1 (6.5)	160.8 (5.9)
BMI (kg/m^2)		
Underweight (<18.5)	0%	1%
Healthy (18.5–24.9)	29%	32%
Overweight (25–29.9)	51%	40%
Obese (30–39.9)	20%	26%
Severely obese (≥40)	0%	2%
Ever smoked regularly	67%	39%
High alcohol intake (units per week: >21 men, >14 women)	22%	5%
Prudent diet score	-0.6 (2.1)	0.7 (1.7)
Dallosso physical activity score	60.9 (15.3)	59.0 (15.7)
Social class (manual)	59%	59%
Home ownership (not owned or mortgaged)	19%	22%
Number of systems medicated	1 (0, 2)	1 (1, 2)
Anxiety (HAD-A score)	4 (2, 6)	5 (2, 8)
Depression (HAD-D score)	2 (1, 3)	2 (1, 4)
Self-rated health		
Excellent	13%	8%
Very good	38%	32%
Good	38%	44%
Fair	10%	14%
Poor	1%	1%
Mortality events		
Death (all-cause)	36%	26%
Death (cardiovascular-related cause)	11%	5%
Death (cancer-related cause)	15%	11%

Follow-up period lasted from baseline (1998–2004) until 31st December 2018.
HAD-A: Anxiety component of the Hospital Anxiety and Depression Scale.
HAD-D: Depression component of the Hospital Anxiety and Depression Scale.

3.3. Associations between participant characteristics and all-cause mortality

Hazard ratios for all-cause mortality according to each participant characteristic are presented in Table 3. Among men and women, the following were associated with increased mortality risk in unadjusted analysis: older age; obesity; ever smoking; lower physical activity; poorer diet quality; leaving school before age 15 years; not owner-occupying one's home; greater numbers of systems medicated; higher depression scores; and poorer SRH. Higher anxiety scores were only related to increased risk of mortality among women. Associations regarding age, smoking status (men), physical activity, diet quality, age left education (men), number of systems medicated (men), and SRH remained significant in mutually-adjusted analysis. For example, hazard ratios (95% CI) for mortality per lower category of SRH were 1.22 (1.10,1.36) among men and 1.17 (1.01,1.35) among women in mutually-adjusted analysis. Birthweight and conditional infant weight gain were not related to risk of mortality among men or women.

3.4. Sensitivity analyses

Associations between participant characteristics and risk of cardiovascular-related mortality and cancer-related mortality are presented in Supplementary Tables 1 and 2. For many participant characteristics, the direction of association was similar compared to the analysis of all-cause mortality. However, fewer associations were statistically significant, perhaps due to the smaller numbers of cause-specific mortality events experienced by participants.

4. Discussion

We have explored correlates of SRH across the lifecourse and examined these factors in relation to all-cause mortality in a community-dwelling cohort of older men and women. Modifiable lifestyle factors, such as low physical activity and obesity, were related to poorer SRH in the seventh decade after accounting for social class, housing tenure and comorbidity level. Poorer SRH remained a risk factor for mortality in mutually-adjusted analysis, which also accounted for age, BMI, health behaviours, socioeconomic factors, comorbidity level and depression score, suggesting the possibility that there are unmeasured characteristics which may account for the association between SRH and mortality. Similar findings were observed among men and women.

We undertook this work as we wanted to consider factors across someone's lifecourse that might be important for SRH. The early life factors we examined, including birthweight, weight at one year and conditional infant weight gain, were not associated with SRH in later life in our population, and nor was age left full-time education. Lack of association with birthweight was consistent with previous research. Although previous twin studies have examined the associations between birthweight and the offspring's risk for poor self-perceived health independent of shared environmental or genetic factors [24], reporting that lower birthweights were associated with lower SRH in early

Table 2
Odds ratios for being in a worse category of self-rated health according to each exposure.

Exposure	Men				Women			
	Unadjusted		Mutually-adjusted		Unadjusted		Mutually-adjusted	
	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value
Age (z-score)	1.06 (0.97, 1.17)	0.179			1.08 (0.98, 1.19)	0.117		
Birthweight (z-score)	1.02 (0.93, 1.12)	0.612			0.95 (0.86, 1.04)	0.284		
Weight at age one year (z-score)	0.99 (0.90, 1.08)	0.750			0.93 (0.85, 1.03)	0.161		
Conditional infant weight gain (z-score)	0.97 (0.89, 1.07)	0.552			0.94 (0.86, 1.04)	0.224		
Height (z-score)	0.97 (0.89, 1.06)	0.523			**0.83 (0.76, 0.92)**	**<0.001**	**0.88 (0.79, 0.97)**	**0.012**
BMI (kg/m^2): Underweight/healthy (<25)	1.00	-	1.00	-	1.00	-	1.00	-
Overweight (25–29.9)	**1.29 (1.05, 1.60)**	**0.017**	1.09 (0.87, 1.36)	0.439	**1.50 (1.20, 1.89)**	**<0.001**	1.26 (0.99, 1.60)	0.062
Obese (≥30)	**2.17 (1.66, 2.82)**	**<0.001**	**1.60 (1.21, 2.11)**	**0.001**	**2.40 (1.86, 3.10)**	**<0.001**	**1.65 (1.25, 2.17)**	**<0.001**
Ever smoked regularly	**1.54 (1.27, 1.87)**	**<0.001**	1.18 (0.96, 1.45)	0.118	**1.38 (1.13, 1.69)**	**0.001**	0.99 (0.80, 1.23)	0.950
High alcohol intake	0.93 (0.75, 1.17)	0.546			0.90 (0.57, 1.42)	0.647		
Dallosso physical activity score (z-score)	**0.71 (0.64, 0.78)**	**<0.001**	**0.83 (0.75, 0.92)**	**<0.001**	**0.65 (0.59, 0.72)**	**<0.001**	**0.77 (0.69, 0.85)**	**<0.001**
Prudent diet score (z-score)	**0.89 (0.81, 0.97)**	**0.011**	0.92 (0.83, 1.01)	0.090	**0.79 (0.72, 0.87)**	**<0.001**	**0.86 (0.78, 0.96)**	**0.006**
Left school before age 15	0.96 (0.76, 1.21)	0.711			1.28 (0.99, 1.66)	0.061		
Social class (manual)	**1.26 (1.04, 1.52)**	**0.016**	1.11 (0.90, 1.36)	0.324	**1.24 (1.02, 1.50)**	**0.035**	0.98 (0.79, 1.21)	0.849
Home ownership (not owned or mortgaged)	**1.89 (1.49, 2.39)**	**<0.001**	**1.35 (1.04, 1.75)**	**0.024**	**1.93 (1.52, 2.44)**	**<0.001**	1.08 (0.83, 1.41)	0.548
Number of systems medicated (per unit increase)	**1.88 (1.73, 2.05)**	**<0.001**	**1.62 (1.47, 1.77)**	**<0.001**	**1.77 (1.64, 1.91)**	**<0.001**	**1.53 (1.41, 1.66)**	**<0.001**
Anxiety score (z-score)	**1.56 (1.42, 1.72)**	**<0.001**	1.05 (0.94, 1.18)	0.368	**2.00 (1.80, 2.22)**	**<0.001**	**1.48 (1.30, 1.68)**	**<0.001**
Depression score (z-score)	**2.35 (2.12, 2.61)**	**<0.001**	**1.89 (1.67, 2.15)**	**<0.001**	**2.32 (2.08, 2.59)**	**<0.001**	**1.65 (1.45, 1.88)**	**<0.001**

Odds ratios were estimated from ordinal logistic regression models; odds ratios are presented per sex-specific SD increase in each exposure or for the presence versus absence of each exposure or, in the case of BMI, compared to the underweight/healthy BMI category
High alcohol intake was defined as >21 units per week for men and >14 units per week for women
Statistically significant associations ($p<0.05$) are highlighted in bold
Anxiety and depression scores were ascertained using the Hospital Anxiety and Depression Scale

adulthood, these typically relate to individuals with much lower birthweights than was apparent in our study, where prematurity was typically associated with poor survival rates, and twin pregnancies were excluded. Data relating early life factors to SRH in late midlife are uncommon. A longitudinal household survey research study conducted in Japan of participants aged 50–75 years examined lifecourse outcomes of birthweight, reporting that low birthweight (lower than recorded in our own study, with low birthweights making up over 10% of the sample) was significantly associated with adverse outcomes in early life including school performance and SRH, but not with educational attainment and primary job status in adulthood. [25].

Exercise and a healthy diet are well-known determinants of better SRH [11]. Our study has confirmed such results, highlighting the value of addressing these lifestyle factors in midlife, although of course we cannot confirm direction of association. We have previously demonstrated that behaviour change is possible even in advanced older age with promising results [26]. Hence considering how to support change in diet where appropriate is valuable, as this study demonstrates benefits.

Depressive symptoms in older adults were associated with greater decline in SRH over 2 years in a US study undertaken some years ago [27] and more recently, anxiety and depression have also been found to be associated with poorer SRH and perceived life satisfaction in older adults [28]. While anxiety and depression were relatively uncommon in our cohort, our findings highlight the importance of mental health to SRH in older adults, and to assess mental wellbeing in older adults at all points of clinical interaction.

Finally, our results are consistent with previous studies that have shown that poor SRH is associated with higher mortality risk [4]. The long-term predictive value of SRH in relation to mortality has previously been found to be poorer than that of short-term predictability among older adults [29,30] so our findings are reassuring regarding long term predictive capacity for this simple measure.

This study has a number of limitations and strengths. We were able to examine longitudinal relationships between exposures in relation to subsequent mortality where deaths were available over a long follow-up ranging from baseline (1998–2004) to December 2018. Characteristics in early life are available in the HCS which provide a rare resource for examining long term effects of early life determinants on disease risk in later life. The data used in the study for generating mortality outcomes were from routine data generated from linking the HCS data with mortality data. A limitation of this study is the use of self-reported information on physical activity and diet quality which may be affected by recall bias. In addition, the occupations of married women were not taken into account when determining their social class as, due to the limited career opportunities of married women born in the 1930s, their husband's occupation was used as a marker of their occupational social class in this cohort. Furthermore, participants were all Caucasian and recruited from the relatively affluent county of Hertfordshire so these findings may be less generalisable to other participants of this age range. However, the HCS has been found to be broadly comparable with the nationally representative Health Survey for England [17]. While we do not have data relating to accidental deaths or death by suicide, we do present sensitivity analyses for cancer-related and cardiovascular-related mortality. Of note, in this study we have presented data by system medicated, as multimorbidity is a readily accessible tool which has been strongly associated with SRH in other studies [31]. It is of course possible that some comorbidities might show stronger associations with SRH but small participant numbers for some individual comorbidities of interest did not allow us to consider this further, and it was not an *a priori* aim of this study. Finally, we do not hold information regarding social support in this sample of the cohort and so were unable to include this in our analyses, but we recognise the contribution that social support makes, especially to lifestyle choices [32].

Table 3
Hazard ratios for all-cause mortality according to each exposure.

Exposure	Men				Women			
	Unadjusted		Mutually-adjusted		Unadjusted		Mutually-adjusted	
	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value
Age (z-score)	**1.48 (1.36,1.61)**	**<0.001**	**1.39 (1.26,1.53)**	**<0.001**	**1.39 (1.25,1.54)**	**<0.001**	**1.40 (1.25,1.58)**	**<0.001**
Birthweight (z-score)	1.02 (0.94,1.11)	0.628			1.05 (0.94,1.16)	0.396		
Weight at age one year (z-score)	0.99 (0.91,1.08)	0.871			0.95 (0.86,1.06)	0.366		
Conditional infant weight gain (z-score)	0.99 (0.91,1.07)	0.749			0.94 (0.85,1.04)	0.237		
Height (z-score)	0.93 (0.85,1.00)	0.065			0.97 (0.87,1.07)	0.533		
BMI (kg/m^2): Underweight / healthy (<25)	1.00	-	1.00	-	1.00	-	1.00	-
Overweight (25–29.9)	0.86 (0.71,1.05)	0.131	**0.76 (0.63,0.93)**	**0.006**	1.26 (0.97,1.62)	0.082	1.12 (0.86,1.45)	0.409
Obese (≥30)	**1.34 (1.07,1.67)**	**0.010**	1.08 (0.86,1.36)	0.514	**1.48 (1.13,1.94)**	**0.004**	1.14 (0.86,1.52)	0.358
Ever smoked regularly	**1.84 (1.52,2.24)**	**<0.001**	**1.59 (1.30,1.94)**	**<0.001**	**1.30 (1.05,1.60)**	**0.014**	1.17 (0.95,1.45)	0.140
High alcohol intake	0.99 (0.81,1.20)	0.890			1.11 (0.68,1.81)	0.672		
Dallosso physical activity score (z-score)	**0.81 (0.74,0.87)**	**<0.001**	**0.89 (0.82,0.96)**	**0.004**	**0.74 (0.67,0.82)**	**<0.001**	**0.83 (0.75,0.93)**	**0.001**
Prudent diet score (z-score)	**0.87 (0.80,0.94)**	**0.001**	**0.90 (0.83,0.99)**	**0.025**	**0.81 (0.73,0.90)**	**<0.001**	**0.85 (0.76,0.94)**	**0.002**
Left school before age 15	**1.79 (1.49,2.14)**	**<0.001**	**1.24 (1.00,1.53)**	**0.047**	**1.36 (1.06,1.76)**	**0.016**	0.85 (0.64,1.13)	0.265
Social class (manual)	1.12 (0.94,1.33)	0.199			1.11 (0.90,1.37)	0.329		
Home ownership (not owned or mortgaged)	**1.57 (1.30,1.90)**	**<0.001**	1.12 (0.92,1.37)	0.266	**1.39 (1.10,1.75)**	**0.006**	1.09 (0.85,1.40)	0.479
Number of systems medicated (per unit increase)	**1.37 (1.29,1.46)**	**<0.001**	**1.22 (1.13,1.31)**	**<0.001**	**1.18 (1.11,1.26)**	**<0.001**	1.07 (0.99,1.15)	0.102
Anxiety score (z-score)	1.06 (0.98,1.15)	0.129			**1.11 (1.00,1.22)**	**0.048**	0.99 (0.88,1.12)	0.901
Depression score (z-score)	**1.24 (1.16,1.34)**	**<0.001**	1.05 (0.97,1.14)	0.248	**1.20 (1.09,1.31)**	**<0.001**	1.07 (0.94,1.20)	0.316
Self-rated health (per lower category)	**1.47 (1.33,1.61)**	**<0.001**	**1.22 (1.10,1.36)**	**<0.001**	**1.39 (1.23,1.57)**	**<0.001**	**1.17 (1.01,1.35)**	**0.038**

Hazard ratios were estimated from Cox regression models; hazard ratios are presented per sex-specific SD increase in each exposure or for the presence versus absence of each exposure or, in the case of BMI, compared to the underweight/healthy BMI category
High alcohol intake was defined as >21 units per week for men and >14 units per week for women
Statistically significant associations ($p<0.05$) are highlighted in bold
Anxiety and depression scores were ascertained using the Hospital Anxiety and Depression Scale

5. Conclusions

In conclusion, SRH, has again been demonstrated to be an important predictor of future mortality. Our study provides valuable insights on the correlates of SRH throughout the lifecourse; while early life factors such as birthweight and age at leaving school were not associated with later SRH, modifiable lifestyle factors in late midlife such as diet, physical activity, obesity and smoking were. We suggest that the period immediately after retirement may represent an opportunity when individuals are amenable to lifestyle modification that is associated with better health in their subsequent years, as they have more time to make, and reinforce, lifestyle changes, and the motivation to do so. This now requires well conducted studies to explore whether this might be possible, and how it is best achieved. As an epidemiological study, it is of course not possible to determine direction of causality. The strong relationships we observed with multimorbidity might be explored further in other large patient samples, to better understand which comorbidities have the greatest effect.

Compliance with Ethical Standards

NA

Ethical approval

Ethical approval was obtained from the Hertfordshire and Bedfordshire Local Research Ethics Committee. Permission to obtain a HES extract for HCS participants was granted by the Ethics and Confidentiality Committee of the National Information Governance Board and NHS Digital.

Declaration of interests

EMD declares consultancy and speaker fees from Pfizer, UCB and Lilly. NCH reports personal fees, consultancy, lecture fees and honoraria from Alliance for Better Bone Health, AMGEN, MSD, Eli Lilly, UCB, Kyowa Kirin, Servier, Shire, Theramex, Consilient Healthcare and Internis Pharma, outside the submitted work. The remaining authors declare that they have no conflicts of interest.

Human and Animal Rights

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

All study participants provided written informed consent for the investigations they underwent and for researchers to access their medical records in the future.

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CRediT authorship contribution statement

RR Investigation, Writing - Original Draft; **LDW** Methodology, Formal analysis, Writing - Original Draft; **EMD** Conceptualization, Writing - Review & Editing, Supervision, Project administration; **CC** Conceptualization; **NCH** Writing - Review & Editing.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.glmedi.2024.100085.

References

[1] M. Wuorela, S. Lavonius, M. Salminen, T. Vahlberg, M. Viitanen, L. Viikari, Self-rated health and objective health status as predictors of all-cause mortality among older people: a prospective study with a 5-, 10-, and 27-year follow-up, BMC Geriatr. 20 (1) (2020) 120. Mar 30.

[2] C. Darviri, G. Fouka, C. Gnardellis, A.K. Artemiadis, X. Tigani, E.C. Alexopoulos, Determinants of self-rated health in a representative sample of a rural population: a cross-sectional study in Greece, Int J. Environ. Res Public Health 9 (3) (2012 Mar) 943–954.

[3] C.R. Clark, M.J. Ommerborn, K. Moran, K. Brooks, J. Haas, D.W. Bates, et al., Predicting self-rated health across the life course: health equity insights from machine learning models, J. Gen. Intern Med 36 (5) (2021 May) 1181–1188.

[4] M. Jylhä, What is self-rated health and why does it predict mortality? Towards a unified conceptual model, Soc. Sci. Med 69 (3) (2009 Aug) 307–316.

[5] G. Verropoulou, Determinants of change in self-rated health among older adults in Europe: a longitudinal perspective based on SHARE data, Eur. J. Ageing 9 (4) (2012 Dec) 305–318.

[6] T. Boerma, A.R. Hosseinpoor, E. Verdes, S. Chatterji, A global assessment of the gender gap in self-reported health with survey data from 59 countries, BMC Public Health 16 (1) (2016 Jul 30) 675.

[7] J. Ford, M. Spallek, A. Dobson, Self-rated health and a healthy lifestyle are the most important predictors of survival in elderly women, Age Ageing 37 (2) (2008 Mar) 194–200.

[8] M.E. McCullough, J.P. Laurenceau, Gender and the natural history of self-rated health: a 59-year longitudinal study, Health Psychol. 23 (6) (2004 Nov) 651–655.

[9] R. Balkrishnan, R.T. Anderson, D. Bowton, Self-reported health status predictors of healthcare services utilization and charges in elderly asthmatic patients, J. Asthma 37 (5) (2000 Aug) 415–423.

[10] M. Södergren, J. Sundquist, S.E. Johansson, K. Sundquist, Physical activity, exercise and self-rated health: a population-based study from Sweden, BMC Public Health 8 (1) (2008 Oct 7) 352.

[11] G. Verropoulou, Key elements composing self-rated health in older adults: a comparative study of 11 European countries, Eur. J. Ageing 6 (3) (2009 Sep) 213–226.

[12] J. Wang, Y. Cai, X. Ren, B. Ma, O. Chen, The effect of body mass index on self-rated health in middle-aged and older adults: evidence from the China health and retirement longitudinal study, Aging Clin. Exp. Res 35 (12) (2023 Dec) 2929–2939.

[13] R. Lintuaho, M. Saltychev, J. Pentti, J. Vahtera, S. Stenholm, Physical activity and self-rated health during retirement transition: a multitrajectory analysis of concurrent changes among public sector employees, BMJ Open 13 (9) (2023 Sep 29) e073876.

[14] C. Coustaury, E. Jeannot, A. Moreau, C. Nietge, A. Maharani, L. Richards, P. Präg, Subjective socioeconomic status and self-rated health in the English longitudinal study of aging: a fixed-effects analysis, Soc. Sci. Med 336 (2023 Nov) 116235.

[15] R. Ping, T. Oshio, Educational inequalities in self-rated health and their mediators in late adulthood: comparison of China and Japan, PLoS One 18 (9) (2023 Sep 15) e0291661.

[16] D.J. Barker, P.D. Winter, C. Osmond, B. Margetts, S.J. Simmonds, Weight in infancy and death from ischaemic heart disease, Lancet 2 (8663) (1989) 577–580. Sep 9.

[17] H. Syddall, A. Aihie Sayer, E. Dennison, H. Martin, D. Barker, C. Cooper, et al., Cohort profile: the Hertfordshire Cohort study, Int. J. Epidemiol. 34 (6) (2005 Dec 1) 1234–1242.

[18] R. Rambukwella, L.D. Westbury, C. Pearse, K.A. Ward, C. Cooper, E.M. Dennison, Hospital admissions and mortality over 20 years in community-dwelling older people: findings from the Hertfordshire Cohort Study, Aging Clin. Exp. Res (2023 Sep 13).

[19] H.E. Syddall, S.J. Simmonds, S.A. Carter, S.M. Robinson, E.M. Dennison, C. Cooper, et al., The Hertfordshire Cohort Study: an overview, F1000Res 8 (2019 Jan 21) 82.

[20] H.E. Syddall, A.A. Sayer, S.J. Simmonds, C. Osmond, V. Cox, E.M. Dennison, et al., Birth weight, infant weight gain, and cause-specific mortality: the Hertfordshire Cohort Study, Am. J. Epidemiol. 161 (11) (2005 Jun 1) 1074–1080.

[21] H.M. Dallosso, K. Morgan, E.J. Bassey, S.B. Ebrahim, P.H. Fentem, T.H. Arie, Levels of customary physical activity among the old and the very old living at home, J. Epidemiol. Community Health 42 (2) (1988 Jun 1) 121–127.

[22] Office of Population Censuses and Surveys. (1990). Standard occupational classification, Vol 1 Structure and definition of major, minor and unit groups. London. HMSO.

[23] Ware J., Kosinski M., Gandek B. SF-36 Health Survey: Manual & Interpretation Guide. Lincoln, RI: QualityMetric Incorporated. 1993 Jan 1;

[24] M.A. Mosing, S. Cnattingius, M. Gatz, J.M. Neiderhiser, N.L. Pedersen, Associations between fetal growth and self-perceived health throughout adulthood: a co-twin control study, Behav. Genet 46 (3) (2016 May) 457–466.

[25] M. Matsushima, S. Shimizutani, H. Yamada, Life course consequences of low birth weight: evidence from Japan, J. Jpn. Int. Econ. 50 (2018 Dec 1) 37–47.

[26] I. Bloom, J. Zhang, J. Hammond, G. Bevilacqua, W. Lawrence, K.A. Ward, et al., Impact of the COVID-19 pandemic on community-dwelling older adults: a longitudinal qualitative study of participants from the Hertfordshire Cohort Study, PLoS One 17 (10) (2022 Oct 14) e0275486.

[27] B. Han, Depressive symptoms and self-rated health in community-dwelling older adults: a longitudinal study, J. Am. Geriatr. Soc. 50 (9) (2002 Sep) 1549–1556.

[28] I. Rouch, E. Achour-Crawford, F. Roche, C. Castro-Lionard, B. Laurent, G. Ntougou Assoumou, R. Gonthier, J.C. Barthelemy, B. Trombert, Seven-year predictors of self-rated health and life satisfaction in the elderly: the PROOF study, J. Nutr. Health Aging 18 (9) (2014 Nov) 840–847.

[29] Y. Benyamini, T. Blumstein, A. Lusky, B. Modan, Gender differences in the self-rated health-mortality association: is it poor self-rated health that predicts mortality or excellent self-rated health that predicts survival? Gerontologist 43 (3) (2003 Jun) 396–405, discussion 372-375.

[30] C. Murata, T. Kondo, K. Tamakoshi, H. Yatsuya, H. Toyoshima, Determinants of self-rated health: could health status explain the association between self-rated health and mortality? Arch. Gerontol. Geriatr. 43 (3) (2006) 369–380, 25.

[31] S. Ansari, A. Anand, B. Hossain, Exploring multimorbidity clusters in relation to healthcare use and its impact on self-rated health among older people in India, PLOS Glob. Public Health 3 (12) (2023 Dec 28) e0002330.

[32] M. Town, P. Eke, G. Zhao, C.W. Thomas, J. Hsia, C. Pierannunzi, K. Hacker, Racial and ethnic differences in social determinants of health and health-related social needs among adults - behavioral risk factor surveillance system, United States, 2022, MMWR Morb. Mortal. Wkly Rep. 73 (9) (2024) 204–208. Mar 7.