OPEN ACCESS

Wealth and mortality at older ages: a prospective cohort study

Panayotes Demakakos, Jane P Biddulph, Martin Bobak, Michael G Marmot

Department of Epidemiology and Public Health, University College London, London, UK

Correspondence to
Dr Panayotes Demakakos, Department of Epidemiology and Public Health, University College London, London WC1E 6BT, UK; p.demakakos@ucl.ac.uk

ABSTRACT

Background Despite the importance of socioeconomic position for survival, total wealth, which is a measure of accumulation of assets over the life course, has been underinvestigated as a predictor of mortality. We investigated the association between total wealth and mortality at older ages.

Methods We estimated Cox proportional hazards models using a sample of 10 305 community-dwelling individuals aged ≥50 years from the English Longitudinal Study of Ageing.

Results 2401 deaths were observed over a mean follow-up of 9.4 years. Among participants aged 50–64 years, the fully adjusted HRs for mortality were 1.21 (95% CI 0.92 to 1.59) and 1.77 (1.35 to 2.33) for those in the intermediate and lowest wealth tertiles, respectively, compared with those in the highest wealth tertile. The respective HRs were 2.54 (1.27 to 5.09) and 3.73 (1.86 to 7.45) for cardiovascular mortality and 1.36 (0.76 to 2.42) and 2.53 (1.45 to 4.41) for other non-cancer mortality. Wealth was not associated with cancer mortality in the fully adjusted model. Similar but less strong associations were observed among participants aged ≥65 years. The use of repeated measurements of wealth and covariates brought about only minor changes, except for the association between wealth and cardiovascular mortality, which became less strong in the younger participants. Wealth explained the associations between paternal occupation at age 14 years, education, occupational class, and income and mortality.

Conclusions There are persisting wealth inequalities in mortality at older ages, which only partially are explained by established risk factors. Wealth appears to be more strongly associated with mortality than other socioeconomic position measures.

Compelling evidence suggests that socioeconomic position is strongly associated with adult mortality[1–4] including mortality from cardiovascular[2 3 5] and other causes[2 3 6–8] and most[2 9] but not all types of cancer.[3 10] Except for colorectal, breast and prostate cancer,[3 10–12] typically the association between socioeconomic position measures such as education and occupational class and mortality is inversely graded; the higher the socioeconomic position of a person the lower their chance of dying.

Socioeconomic inequalities in mortality are a major public health issue and pose a great challenge for societies as the burden associated with them is immense. In England and Wales, in 2003, it was estimated that 2.3 million years of life were prematurely lost among people aged 30–59 years as a result of socioeconomic inequalities,[13] while

inequality-related deaths in the European Union, in 2004, amounted to approximately 707 000.[14] On a relative scale, socioeconomic inequalities in mortality tend to be smaller in older people compared with middle-aged people.[3 15 16] Nevertheless, the public health importance of socioeconomic inequalities in mortality at older ages is great. At older ages, even small differences in the relative risk of mortality translate into large differences in the absolute risk of mortality with an excess of deaths among people of lower socioeconomic position compared with those of higher socioeconomic position.[1] Evidence suggests that socioeconomic inequalities in the absolute risk of mortality at older ages are substantial and, despite few contradictory findings,[15] monotonically increase as people get older.[3 15]

Research on socioeconomic inequalities in mortality at older ages is relatively limited[16] and several important questions have yet to be answered. First, it is unclear how best to measure socioeconomic position at older ages[17] and which aspects of socioeconomic position are mostly relevant to mortality at older ages. For older people, the majority of whom have retired and are no longer economically active, it maybe access to and ownership of financial resources and assets that is important for their survival and well-being. Commonly used indicators of socioeconomic position such as education, occupational class and income do not measure life-time accumulation and control over financial resources and assets. Furthermore, education and occupational class refer to a relatively distant past of older people and are no longer measures of contemporary socioeconomic position. For these reasons, these indicators of socioeconomic position may be less appropriate to use in older people. Second, it is vital to identify the modifiable pathways involved in socioeconomic inequalities in mortality. Recent contradictory findings about whether the use of repeated measurements of unhealthy behaviours fully explain socioeconomic inequalities in mortality[18] or not[19] has fuelled interest in re-examining unhealthy behaviours as potential mediators of the association between socioeconomic position and mortality.[20]

To address these issues, we investigated whether there are important wealth inequalities in all-cause and cause-specific mortality in a sample of middle-aged and older people. We used total net non-pension household wealth, which is a measure of current socioeconomic position that reflects accumulation of assets over the life course. Despite its potential as a major socioeconomic determinant of mortality, total wealth has been underinvestigated in epidemiological studies of older people.

To address the role of unhealthy behaviours as modifiable mediators, we examined whether smoking and physical inactivity as well as obesity explained the association between wealth and mortality. We also examined whether elevated depressive symptoms, another potentially modifiable risk factor, might mediate the association, although elevated depressive symptoms may reflect life-time history of depression and thus to a certain extent be a confounder. As evidence suggests that adjustment for repeated measurements of unhealthy behaviours is better than adjustment for only the baseline measurement,[18] we estimated models that included time-varying covariates. To expand on the current state of knowledge and account for wealth fluctuations over time, we also included time-varying wealth in our models. To establish whether wealth was a strong predictor of mortality independent of other socioeconomic position measures and thus preferential to use when studying socioeconomic inequalities in older people, we adjusted our models for a series of childhood and adult socioeconomic position measures. Finally, we examined whether wealth, as an indicator of current socioeconomic position, explains the associations between mortality and other widely used indicators of socioeconomic position such as education and occupational class.

METHODS
Study population
The English Longitudinal Study of Ageing (ELSA) is a prospective observational study of community-dwelling people aged 50 years and over in England. At baseline, in 2002–2003, the sample comprised 11 391 core participants who were recruited from households that had earlier participated in the Health Survey for England in 1998, 1999 and 2001. The Health Survey for England is an annual health examination survey, which each year recruits a different nationally representative sample using a multistaged stratified random probability design. After the baseline, follow-up interviews took place every 2 years and health examinations every 4 years (the first health examination was in 2004–2005). A detailed description of the study can be found at: http://www.elsa-project.ac.uk/. The analytical sample comprised 10 305 after the exclusion of 362 participants with proxy or partial interviews, 459 participants who did not consent to the mortality linkage, 5 participants who died the same month they granted their baseline interview and 260 participants with missing values in baseline variables (excluding body mass index (BMI)).

Assessment of household wealth
The ELSA has collected detailed information on different dimensions of wealth both at baseline and each of the follow-up interviews. We used total net non-pension household wealth, which is a summary measure of the value of financial, physical and housing wealth owned by the household (ie, a single respondent or a responding couple along with any dependent individuals) minus any debt. The estimation of this variable was based on 22 different wealth and debt components, which were either observed or imputed. The imputed wealth and debt components were integral part of the original ELSA data set and generated by the data depositors and not the authors of this study. Most of these imputations referred to incomplete values in one or two components and were based on information that the participants provided about the upper and lower boundaries within which the actual values of those components lay. A detailed description of wealth and its components can be found at: http://bit.ly/1yrRgHd and http://bit.ly/1awp6iZ. As our aim

was to study wealth inequalities in mortality, we categorised wealth into tertiles.

Mortality
Death registrations up to February 2013 were obtained from the Office for National Statistics for all consenting participants. Deaths were classified according to International Classification of Diseases (ICD) 10th Edition. Deaths with ICD10 codes C00 to C97 were classified as cancer deaths and those with ICD10 codes I00 to I99 as cardiovascular deaths. All remaining deaths were classified as other.

Covariates
Age, sex and marital status were measured as demographic confounders. Paternal (or main carer's) occupational class when participants were 14 years old, education, occupational class, income, smoking, physical activity, measured BMI and elevated depressive symptoms were also measured. We used repeated measurements of wealth, physical activity and depressive symptoms to generate time-varying variables. To minimise non-response bias in analyses involving time-varying variables, we imputed the missing values in these three variables. We could not impute the missing values in smoking, because there was not enough variation in this variable over time, and consequently did not derive a time-varying smoking variable. BMI was not measured in all waves of the study, and thus we did not have the necessary data to derive a time-varying BMI variable. Among the 10 305 participants with complete baseline data (excluding BMI data), 5758 (including 2401 who died after the baseline) did not have complete data on wealth tertiles, physical activity and depressive symptoms at all four follow-up interviews. We imputed all missing values and censored the imputed data at the date of death. We also imputed missing values in the baseline BMI categories variable (n=944; in our analyses BMI was the only baseline variable with missing values). We defined wealth tertiles across the analyses using the baseline wealth distribution.

Statistical analysis
Cox proportional hazard regression analyses were performed to investigate the associations between wealth and all-cause and cause-specific mortality. Survival time was measured as the amount of time that had elapsed from the date of baseline interview to the first of either the date of death or censoring (ie, February 2013). Significant interactions by age, but not sex, were identified using the likelihood ratio test. For this reason, all analyses were stratified into two age groups: 50–64 and 65 years or older. We used the cut point of 65 years because that was the national state pension age for men and the mean age of our sample. The use of this cut point resulted in two age groups of similar size with an adequate number of cases per group. The Cox regression models were initially adjusted for age, sex and marital status, then, in addition, for smoking and physical activity, and finally for BMI and elevated depressive symptoms. We repeated the survival analysis using repeated measurements of wealth, physical activity and depressive symptoms. We also examined whether the association between wealth and all-cause mortality persisted after adjustment for other socioeconomic position measures. Further, we examined whether wealth mediated the associations between either childhood or adult socioeconomic position measures and all-cause mortality. We confirmed that the proportionality assumption was met using survival plots and the Schoenfeld residuals test.

To investigate the potential influence of reverse causality, that is, baseline chronic diseases and subsequent proximity to death leading to a decrease in wealth, we repeated our analyses after excluding people with major chronic conditions (see web table 1). To explore whether the use of any imputed wealth data biased our findings, we repeated our analyses after excluding participants with imputed values in any of the 22 baseline wealth and debt components that were generated by the ELSA data depositors (see web table 2).

RESULTS

The lower the wealth of participants the more likely they were to be older, female, non-married, smokers, physically inactive, depressed, obese and of lower socioeconomic position (table 1). There was an inverse dose–response association between wealth and all-cause and cause-specific mortality that was stronger among younger participants (table 2). Wealth was strongly associated with cardiovascular and other mortality (table 2). The adjustment for risk factors only partially explained these

Table 1 The baseline characteristics of 10 305 women and men aged 50 years and over by household wealth

	Household wealth tertiles			
	Wealthiest (≥£203 000)	Intermediate (<£203 000 to ≥£76 020)	Poorest (<£76 020)	p Value*
N	3469	3468	3368	
Mean age (SD)	63.6 (9.3)	64.5 (9.9)	66.9 (10.9)	<0.001
Sex (%)				
Male	1686 (48.6)	1574 (45.4)	1444 (42.9)	
Female	1783 (51.4)	1894 (54.6)	1924 (57.1)	<0.001
Marital status (%)				
Married	2798 (80.7)	2438 (70.3)	1639 (48.7)	
Other	671 (19.3)	1030 (29.7)	1729 (51.3)	<0.001
Smoking (%)				
Current smoker	356 (10.2)	533 (15.4)	942 (28.0)	
Former smoker	1716 (49.5)	1669 (48.1)	1425 (42.3)	
Never-smoker	1397 (40.3)	1266 (36.5)	1001 (29.7)	<0.001
Physical activity at least once a week (%)				
Vigorous intensity	1279 (36.9)	1008 (29.1)	540 (16.0)	
Moderate intensity	1725 (49.7)	1706 (49.2)	1475 (43.8)	
Mild intensity	278 (8.0)	485 (14.0)	760 (22.6)	
Physically inactive	187 (5.4)	269 (7.7)	593 (17.6)	<0.001
Body mass index† (%) (kg/m^2)				
<25	1042 (30.0)	868 (25.0)	868 (25.8)	
25 to <30	1542 (44.5)	1470 (42.4)	1189 (35.3)	
≥30	608 (17.5)	864 (24.9)	910 (27.0)	
Missing	277 (8.0)	266 (7.7)	401 (11.9)	<0.001
Elevated depressive symptoms‡ (%)				
No	3182 (91.7)	2973 (85.7)	2484 (73.8)	
Yes	287 (8.3)	495 (14.3)	884 (26.2)	<0.001
Education (%)				
A-level or higher	1626 (46.9)	872 (25.1)	410 (12.2)	
GCSE/O-level/other qualification	1091 (31.4)	1161 (33.5)	795 (23.6)	
No educational qualifications	752 (21.7)	1435 (41.4)	2163 (64.2)	<0.001
Occupational class (%)				
Managerial and professional occupations	1664 (48.0)	964 (27.8)	393 (11.7)	
Intermediate occupations	999 (28.8)	848 (24.4)	577 (17.1)	
Semiroutine and routine occupations	755 (21.7)	1619 (46.7)	2317 (68.8)	
Never worked	51 (1.6)	37 (1.1)	81 (2.4)	<0.001
Paternal occupational class at age 14 years§ (%)				
Managerial and professional occupations/run own business	1537 (44.3)	890 (25.7)	478 (14.2)	
Intermediate occupations	1020 (29.4)	1187 (34.2)	1118 (33.2)	
Routine occupations/casual jobs/unemployed/disabled	760 (21.9)	1225 (35.3)	1578 (46.8)	
Other (including Armed Forces)	152 (4.4)	166 (4.8)	194 (5.8)	<0.001
Weekly household income tertiles (%)				
Highest (≥£262.79)	1993 (57.5)	1078 (31.1)	430 (12.8)	
Middle (<£262.79 to ≥£155.19)	975 (28.1)	1348 (38.9)	1120 (33.2)	
Lowest (<£155.19)	501 (14.4)	1042 (30.0)	1818 (54.0)	<0.001

*p Values were calculated using χ^2, Kruskal-Wallis and analysis of variance tests for categorical, ordinal and continuous covariates, respectively.
†The missing category was not used in the calculation of the p value.
‡Defined as ≥4 symptoms on the eight-item Center for Epidemiological Studies-Depression scale.
§The 'other' category included 73 participants with missing values and was not used in the calculation of the p value.
GCSE, General Certificate of Secondary Education.

Table 2 The association between household wealth and all-cause and cause-specific mortality by age

	50–64 years Household wealth tertiles			≥65 years Household wealth tertiles		
	Wealthiest	**Intermediate**	**Poorest**	**Wealthiest**	**Intermediate**	**Poorest**
All-cause mortality						
Number of deaths	94	118	196	453	578	962
Deaths/1000 person years	4.6 (3.7–5.6)	6.3 (5.2–7.5)	13.2 (11.5–15.2)	34.3 (31.3–35.6)	40.4 (37.2–43.8)	66.4 (62.3–70.7)
Model 1 HR (95% CI)*	1.00 (reference)	1.42 (1.08 to 1.86)	2.97 (2.30 to 3.82)	1.00 (reference)	1.13 (1.00 to 1.28)	1.66 (1.48 to 1.86)
Model 2 HR (95% CI)†	1.00 (reference)	1.25 (0.95 to 1.64)	1.91 (1.46 to 2.50)	1.00 (reference)	1.07 (0.94 to 1.21)	1.37 (1.21 to 1.54)
Model 3 HR (95% CI)‡	1.00 (reference)	1.21 (0.92 to 1.59)	1.77 (1.35 to 2.33)	1.00 (reference)	1.06 (0.93 to 1.19)	1.34 (1.19 to 1.51)
Cardiovascular mortality						
Number of deaths	11	31	59	141	198	377
Deaths/1000 person years	0.5 (0.3–1.0)	1.6 (1.2–2.3)	4.0 (3.1–5.1)	10.7 (9.0–12.6)	13.8 (12.0–15.9)	26.0 (23.5–28.8)
Model 1 HR (95% CI)*	1.00 (reference)	3.21 (1.61 to 6.39)	7.76 (4.04 to 14.89)	1.00 (reference)	1.24 (1.00 to 1.54)	2.01 (1.65 to 2.46)
Model 2 HR (95% CI)†	1.00 (reference)	2.73 (1.37 to 5.45)	4.19 (2.12 to 8.31)	1.00 (reference)	1.17 (0.94 to 1.46)	1.68 (1.37 to 2.06)
Model 3 HR (95% CI)‡	1.00 (reference)	2.54 (1.27 to 5.09)	3.73 (1.86 to 7.45)	1.00 (reference)	1.14 (0.92 to 1.42)	1.63 (1.33 to 2.00)
Cancer mortality						
Number of deaths	63	59	74	155	172	213
Deaths/1000 person years	3.1 (2.4–3.9)	3.1 (2.4–4.0)	5.0 (4.0–6.3)	11.7 (10.0–13.7)	12.0 (10.4–14.0)	14.7 (12.9–16.8)
Model 1 HR (95% CI)*	1.00 (reference)	1.06 (0.75 to 1.52)	1.73 (1.22 to 2.44)	1.00 (reference)	1.03 (0.83 to 1.29)	1.26 (1.01 to 1.56)
Model 2 HR (95% CI)†	1.00 (reference)	0.95 (0.66 to 1.36)	1.22 (0.84 to 1.76)	1.00 (reference)	0.98 (0.79 to 1.22)	1.07 (0.86 to 1.34)
Model 3 HR (95% CI)‡	1.00 (reference)	0.93 (0.64 to 1.33)	1.15 (0.79 to 1.69)	1.00 (reference)	0.97 (0.78 to 1.21)	1.06 (0.84 to 1.33)
Other mortality						
Number of deaths	20	28	63	157	208	372
Deaths/1000 person years	1.0 (0.6–1.5)	1.5 (1.0–2.2)	4.2 (3.3–5.4)	11.9 (10.2–13.9)	14.5 (12.7–16.6)	25.7 (23.2–28.4)
Model 1 HR (95% CI)*	1.00 (reference)	1.56 (0.88 to 2.77)	4.18 (2.50 to 7.00)	1.00 (reference)	1.15 (0.93 to 1.41)	1.71 (1.41 to 2.08)
Model 2 HR (95% CI)†	1.00 (reference)	1.38 (0.78 to 2.46)	2.75 (1.59 to 4.73)	1.00 (reference)	1.08 (0.87 to 1.32)	1.36 (1.12 to 1.66)
Model 3 HR (95% CI)‡	1.00 (reference)	1.36 (0.76 to 2.42)	2.53 (1.45 to 4.41)	1.00 (reference)	1.08 (0.87 to 1.33)	1.34 (1.10 to 1.63)
Sample sizes						
Number of participants	2012	1850	1507	1457	1618	1861
Person years of follow-up	20 668	18 863	14 869	13 222	14 318	14 492

*Adjusted for age, sex and baseline marital status.
†As model 1, plus adjustment for baseline smoking and baseline physical activity.
‡As model 2, plus adjustment for baseline elevated depressive symptoms and baseline body mass index.

associations, except for the association between wealth and cancer mortality, which was fully explained (table 2). The adjustment for other socioeconomic position measures also did not affect the association between wealth and all-cause mortality (compare model 2, right-hand side panel (Household wealth tertiles), table 3 to model 1, table 2). In contrast, the associations between paternal occupational class at age 14 years, education, occupational class, and income and all-cause mortality were considerably attenuated after adjustment for wealth (see left-hand side panel (Socioeconomic position indicator), table 3). The adjustment for time-varying physical activity and depressive symptoms and the use of time-varying wealth did not much change the results; except for a decrease in the strength of the association between and cardiovascular mortality among those aged 50–64 years that was brought about mostly by the use of time-varying wealth (compare table 4 to table 2).

DISCUSSION

In a national sample of people 50 years or older, we found pronounced gradients in all-cause and cause-specific mortality by total household wealth. Age affected the strength but not the pattern of these associations. Adjustment for covariates neither fully explained the associations, except for cancer mortality, nor affected their dose–response pattern. Additional adjustment for time-varying covariates and the use of time-varying wealth did not change the associations to a great extent. The only

exception was a decrease in the strength of the association between wealth and cardiovascular mortality among participants aged 50–64 years. Wealth was found to be a more powerful predictor of mortality than any other socioeconomic position indicator used in our analyses and explained most of the associations between other socioeconomic position indicators and all-cause mortality in both younger and older participants.

Strengths and weaknesses

Our study is one of the first to thoroughly study wealth inequalities in mortality and the role of wealth in the associations between commonly used socioeconomic position indicators such as education and occupational class and mortality over a long follow-up. The use of a national sample of community dwellers and rich longitudinal data from a well-established survey are strengths of our study. The 10-year follow-up allowed for the investigation of the longer term effect of wealth on the risk of mortality. The quality measurement of wealth minimised the possibility of measurement bias, while the examination of age differences widened the scope of our work.

The use of a selected sample of people who survived at least to the age of 50 years to be included in our sample is a limitation that affects the applicability of our findings to younger generations. Another weakness is the possibility of non-response bias. Although our study had a household response rate at baseline of 70% and was inclusive of the vast majority of people

Table 3 The association between different socioeconomic position indicators and all-cause mortality by age

	Socioeconomic position indicator			Household wealth tertiles		
Age 50–64 years						
Education	A-level or higher	O-level/GCSE	No qualifications	Wealthiest	Intermediate	Poorest
Model 1 HR (95% CI)*	1.00 (reference)	0.99 (0.76 to 1.29)	1.70 (1.35 to 2.15)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	0.85 (0.65 to 1.12)	1.18 (0.92 to 1.52)	1.00 (reference)	1.39 (1.05 to 1.83)	2.75 (2.10 to 3.62)
Occupational class‡	Managerial/professional	Intermediate	Semiroutine/routine			
Model 1 HR (95% CI)*	1.00 (reference)	1.42 (1.06 to 1.90)	1.77 (1.39 to 2.25)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.26 (0.94 to 1.69)	1.23 (0.95 to 1.59)	1.00 (reference)	1.36 (1.03 to 1.80)	2.76 (2.09 to 3.63)
Paternal occupational class at age 14 years§	Managerial/professional/run own business	Intermediate	Routine/casual/unemployed/disabled			
Model 1 HR (95% CI)*	1.00 (reference)	1.47 (1.12 to 1.92)	1.62 (1.25 to 2.10)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.21 (0.92 to 1.58)	1.22 (0.93 to 1.60)	1.00 (reference)	1.37 (1.04 to 1.80)	2.80 (2.15 to 3.64)
Weekly household income tertiles	Highest	Intermediate	Lowest			
Model 1 HR (95% CI)*	1.00 (reference)	1.86 (1.46 to 2.38)	2.23 (1.73 to 2.87)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.53 (1.19 to 1.97)	1.58 (1.20 to 2.07)	1.00 (reference)	1.30 (0.98 to 1.71)	2.47 (1.89 to 3.24)
Age 65 years and older						
Education	A-level or higher	O-level/GCSE	No qualifications	Wealthiest	Intermediate	Poorest
Model 1 HR (95% CI)*	1.00 (reference)	1.07 (0.93 to 1.23)	1.29 (1.14 to 1.46)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	0.99 (0.86 to 1.14)	1.09 (0.96 to 1.25)	1.00 (reference)	1.11 (0.98 to 1.26)	1.60 (1.41 to 1.81)
Occupational class‡	Managerial/professional	Intermediate	Semiroutine/routine			
Model 1 HR (95% CI)*	1.00 (reference)	1.11 (0.97 to 1.27)	1.32 (1.18 to 1.48)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.03 (0.90 to 1.18)	1.12 (0.99 to 1.26)	1.00 (reference)	1.11 (0.98 to 1.26)	1.59 (1.40 to 1.80)
Paternal occupational class at age 14 years§	Managerial/professional/run own business	Intermediate	Routine/casual/unemployed/disabled			
Model 1 HR (95% CI)*	1.00 (reference)	1.16 (1.03 to 1.30)	1.24 (1.11 to 1.40)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.05 (0.93 to 1.18)	1.08 (0.96 to 1.22)	1.00 (reference)	1.12 (0.98 to 1.27)	1.62 (1.44 to 1.83)
Weekly household income tertiles	Highest	Intermediate	Lowest			
Model 1 HR (95% CI)*	1.00 (reference)	1.26 (1.10 to 1.44)	1.34 (1.18 to 1.53)	–	–	–
Model 2 HR (95% CI)†	1.00 (reference)	1.12 (0.97 to 1.29)	1.10 (0.95 to 1.27)	1.00 (reference)	1.10 (0.96 to 1.25)	1.61 (1.41 to 1.82)

*Adjusted for age, sex and baseline marital status.
†As model 1, plus adjustment for baseline tertiles of household wealth.
‡For clarity reasons, results for the small 'never worked' category are not presented.
§For clarity reasons, results for the small 'other' category are not presented.
GCSE, General Certificate of Secondary Education.

Table 4 The association between time-varying household wealth and all-cause and cause-specific mortality by age

	50–64 years Time-varying household wealth tertiles			≥65 years Time-varying household wealth tertiles		
	Wealthiest	**Intermediate**	**Poorest**	**Wealthiest**	**Intermediate**	**Poorest**
All-cause mortality						
Number of deaths	94	118	196	453	578	962
Model 1 HR (95% CI)*	1.00 (reference)	1.53 (1.31 to 1.78)	3.00 (2.61 to 3.45)	1.00 (reference)	1.22 (1.13 to 1.31)	1.68 (1.58 to 1.79)
Model 2 HR (95% CI)†	1.00 (reference)	1.24 (1.06 to 1.44)	1.85 (1.59 to 2.16)	1.00 (reference)	1.13 (1.05 to 1.21)	1.42 (1.32 to 1.51)
Model 3 HR (95% CI)‡	1.00 (reference)	1.20 (1.03 to 1.40)	1.73 (1.47 to 2.02)	1.00 (reference)	1.12 (1.04 to 1.20)	1.39 (1.30 to 1.48)
Cardiovascular mortality						
Number of deaths	11	31	59	141	198	377
Model 1 HR (95% CI)*	1.00 (reference)	2.50 (1.78 to 3.49)	5.16 (3.78 to 7.04)	1.00 (reference)	1.30 (1.15 to 1.47)	1.80 (1.61 to 2.01)
Model 2 HR (95% CI)†	1.00 (reference)	1.92 (1.36 to 2.69)	2.72 (1.93 to 3.84)	1.00 (reference)	1.21 (1.07 to 1.36)	1.53 (1.37 to 1.72)
Model 3 HR (95% CI)‡	1.00 (reference)	1.77 (1.25 to 2.49)	2.40 (1.69 to 3.41)	1.00 (reference)	1.19 (1.05 to 1.34)	1.50 (1.33 to 1.68)
Cancer mortality						
Number of deaths	63	59	74	155	172	213
Model 1 HR (95% CI)*	1.00 (reference)	1.21 (0.98 to 1.51)	1.89 (1.55 to 2.30)	1.00 (reference)	1.13 (0.99 to 1.28)	1.32 (1.17 to 1.48)
Model 2 HR (95% CI)†	1.00 (reference)	1.03 (0.83 to 1.28)	1.32 (1.07 to 1.64)	1.00 (reference)	1.05 (0.93 to 1.20)	1.14 (1.00 to 1.29)
Model 3 HR (95% CI)‡	1.00 (reference)	1.01 (0.81 to 1.25)	1.25 (1.01 to 1.56)	1.00 (reference)	1.04 (0.91 to 1.18)	1.11 (0.98 to 1.26)
Other mortality						
Number of deaths	20	28	63	157	208	372
Model 1 HR (95% CI)*	1.00 (reference)	1.68 (1.23 to 2.28)	4.29 (3.29 to 5.59)	1.00 (reference)	1.24 (1.10 to 1.40)	1.88 (1.70 to 2.08)
Model 2 HR (95% CI)†	1.00 (reference)	1.32 (0.96 to 1.80)	2.48 (1.87 to 3.30)	1.00 (reference)	1.14 (1.01 to 1.29)	1.54 (1.39 to 1.71)
Model 3 HR (95% CI)‡	1.00 (reference)	1.31 (0.96 to 1.79)	2.36 (1.77 to 3.16)	1.00 (reference)	1.14 (1.00 to 1.29)	1.51 (1.36 to 1.69)
Sample sizes						
Number of participants	2012	1850	1507	1457	1618	1861
Person years of follow-up	20 668	18 863	14 869	13 222	14 318	14 492

*Adjusted for age, sex and baseline marital status.
†As model 1, plus adjustment for baseline smoking and time-varying physical activity.
‡As model 2, plus adjustment for time-varying elevated depressive symptoms and baseline body mass index.

who had participated at baseline, we cannot rule out the possibility of non-response bias. Nevertheless, the consistency between the main analyses findings and those of supplementary analyses that excluded participants with major chronic diseases or imputed wealth values suggests that it is unlikely non-response bias to considerably influence our findings. Finally, despite retaining in the sample participants who moved to care homes and other institutions after the baseline, the exclusion of people living in institutions at baseline makes our findings less relevant to institutionalised older people.

Interpretation of the findings
Our findings indicate that there are important wealth inequalities in mortality at older ages. Few, mostly US, studies have studied wealth inequalities in mortality. Notwithstanding methodological differences, their findings largely concur with ours and highlight wealth as an important predictor of mortality.[21–28] Significant wealth inequalities were observed in both participants aged 50–64 years and those aged 65 years or older, but they were much more pronounced in the former age group. The decline in the relative strength of socioeconomic[3 16] and more specifically wealth[21 23 25] inequalities in people aged 65 years or older compared with younger adults is a consistent finding of the literature and accords with the declining strength of the associations between mortality and most risk factors with age, which is likely, in part, to be an effect of survivor bias. Nevertheless, the importance of wealth inequalities for people aged 65 years and older remains as they translate into great differences in the absolute risk of dying. The great difference in the relative risk of premature death between the top and bottom tertile of wealth among

people aged 50–64 years likely indicates the detrimental effect of the accumulation of disadvantage over the life course and identifies a population at risk.

Housing wealth is a component of total wealth. On the basis that the majority of participants who did not own their home were classified in the bottom tertile of the wealth, our findings support earlier findings suggesting that the inverse association between home ownership and mortality risk should be interpreted as part of wealth inequalities in mortality.[29]

Wealth inequalities in cardiovascular mortality were pronounced and persisting. The magnitude and persistence of wealth inequalities in cardiovascular mortality probably indicates a systematic life course effect socioeconomic position on cardiovascular health that might be related to early life programming and mediated by subsequent epigenetic and physiological modifications. Wealth inequalities in cancer mortality were less pronounced and mostly a result of the higher prevalence of unhealthy behaviours among people in the bottom tertile of the wealth distribution. The persisting wealth gradient in mortality from other causes, including respiratory causes, may at least partly reflect the impact of social disadvantage and inadequate housing conditions on respiratory health.

In this study, a set of behavioural and psychosocial risk factors failed to completely account for the observed mortality gradient. A recent study of wealth inequalities in a nationally representative US sample aged 51 years and older reported similar findings.[23] To the extent that our work is comparable with studies of occupational cohorts that did not use total wealth,[18 19] our findings contradict findings suggesting a full explanation of socioeconomic inequalities after adjustment for

time-varying unhealthy behaviours[18] and lend support to those suggesting a partial attenuation.[19] We found that adjustment for time-varying covariates explained only a small additional part of the association between wealth and mortality compared with the conventional analysis that did not use time-varying covariates. The use of time-varying predictor also did not bring about considerable changes, except for the partial attenuation of the association between wealth and cardiovascular mortality among those aged 50–64 years, an indication that fluctuations in wealth at older ages likely are less important for survival than baseline wealth.

The adjustment for paternal occupational class at age 14 years, education, occupational class and household income only slightly affected wealth's association with mortality. These findings indicate that wealth is an appropriate socioeconomic position indicator to use when studying socioeconomic inequalities in health in older adults. Previous findings concur with our findings indicating that wealth remained associated with mortality after adjustment for other socioeconomic position measures[21 22 24 26–28] with any discrepancy stemming from methodological differences such as the use of data from administrative sources.[27] In agreement with our findings, studies also reported full or partial attenuation of the associations between either education or income and mortality after adjustment for wealth,[27 30] except for one instance.[30] The full attenuation of the associations between paternal occupational class, education and occupational class and mortality after adjustment for wealth in our data suggests that wealth accumulation is one of the main pathways through which childhood and adult socioeconomic positions are associated with later life risk of mortality.

Wealth appears to be more strongly associated with the risk of death than any other socioeconomic position indicator at older ages. Future research should propose and test causal models of the most pertinent pathways linking socioeconomic position indicators from different stages of the life course to mortality at older ages in an attempt to improve our understanding of the association between socioeconomic position and mortality.

What is already known on this subject

▸ Our understanding of social inequalities in mortality at older ages remains limited.
▸ It is unclear how best to measure socioeconomic position at older ages and which aspects of socioeconomic position are mostly relevant to mortality at older ages. Wealth, an important socioeconomic position measure that may be mostly appropriate to use when studying middle-aged and older people, has rarely been used in epidemiological research.
▸ It also remains unclear whether unhealthy behaviours, depression and obesity explain the association between socioeconomic position and mortality at middle and older ages.
▸ Finally, to better understand the association between socioeconomic position and mortality over the life course, it is important to establish whether the associations between childhood and early and middle adulthood socioeconomic position and mortality at older ages are explained by contemporary socioeconomic position measured using wealth.

What this study adds

▸ This study is one of the first to thoroughly examine the associations between total net non-pension household wealth and all-cause and cause-specific mortality using repeated measurements of wealth and behavioural and psychosocial factors.
▸ We found important and persisting wealth inequalities in all-cause and cause-specific mortality at older ages. These were more pronounced among people aged 50–64 years. They were less pronounced but still significant among those aged 65 years and older.
▸ We also found that the associations between measures of childhood and young and middle adulthood socioeconomic position and mortality were largely explained by wealth. Wealth was more strongly associated with mortality than any other socioeconomic position indicator and appears to be an excellent socioeconomic position measure to use in studies of middle-aged and older people.
▸ Unhealthy behaviours, elevated depressive symptoms and obesity provided only a partial explanation of the association between wealth and mortality, even when multiple measurements of these factors and wealth were used.
▸ Wealth was more strongly associated with cardiovascular and other non-cancer mortality than cancer mortality.

REFERENCES

1   Marmot MG, Shipley MJ. Do socioeconomic differences in mortality persist after retirement? 25 year follow up of civil servants from the first Whitehall study. *BMJ* 1996;313:1177–80.
2   Mackenbach JP, Stirbu I, Roskam AJ, et al, European Union Working Group on Socioeconomic Inequalities in Health. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med* 2008;358:2468–81.
3   Huisman M, Kunst AE, Bopp M, et al. Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. *Lancet* 2005;365:493–500.
4   Pappas G, Queen S, Hadden W, et al. The increasing disparity in mortality between socioeconomic groups in the United States, 1960 and 1986. *N Engl J Med* 1993;329:103–9.

5 Addo J, Ayerbe L, Mohan KM, *et al*. Socioeconomic status and stroke: an updated review. *Stroke* 2012;43:1186–91.

6 Lorant V, Kunst AE, Huisman M, *et al*. Socio-economic inequalities in suicide: a European comparative study. *Br J Psychiatry* 2005;187:49–54.

7 Cubbin C, LeClere FB, Smith GS. Socioeconomic status and injury mortality: individual and neighbourhood determinants. *J Epidemiol Community Health* 2000;54:517–24.

8 Prescott E, Godtfredsen N, Vestbo J, *et al*. Social position and mortality from respiratory diseases in males and females. *Eur Respir J* 2003;21:821–6.

9 Woods LM, Rachet B, Coleman MP. Origins of socio-economic inequalities in cancer survival: a review. *Ann Oncol* 2006;17:5–19.

10 Menvielle G, Kunst AE, Stirbu I, *et al*. Educational differences in cancer mortality among women and men: a gender pattern that differs across Europe. *Br J Cancer* 2008;98:1012–19.

11 Aarts MJ, Lemmens VE, Louwman MW, *et al*. Socioeconomic status and changing inequalities in colorectal cancer? A review of the associations with risk, treatment and outcome. *Eur J Cancer* 2010;46:2681–95.

12 Strand BH, Kunst A, Huisman M, *et al*. The reversed social gradient: higher breast cancer mortality in the higher educated compared to lower educated. A comparison of 11 European populations during the 1990s. *Eur J Cancer* 2007;43:1200–7.

13 Marmot M, Allen J, Goldblatt P, *et al*. Fair society, healthy lives. The Marmot Review. Strategic review of health inequalities in England post-2010. http://bit.ly/S9lH0l (last accessed Oct 2015).

14 Mackenbach JP, Meerding WJ, Kunst AE. Economic costs of health inequalities in the European Union. *J Epidemiol Community Health* 2011;65:412–19.

15 Menvielle G, Leclerc A, Chastang JF, *et al*. Socioeconomic inequalities in cause specific mortality among older people in France. *BMC Public Health* 2010;10:260.

16 Huisman M, Read S, Towriss CA, *et al*. Socioeconomic inequalities in mortality rates in old age in the World Health Organization Europe region. *Epidemiol Rev* 2013;35:84–97.

17 Grundy E, Holt G. The socioeconomic status of older adults: how should we measure it in studies of health inequalities? *J Epidemiol Community Health* 2001;55:895–904.

18 Stringhini S, Sabia S, Shipley M, *et al*. Association of socioeconomic position with health behaviors and mortality. *JAMA* 2010;303:1159–66.

19 Stringhini S, Dugravot A, Shipley M, *et al*. Health behaviours, socioeconomic status, and mortality: further analyses of the British Whitehall II and the French GAZEL prospective cohorts. *PLoS Med* 2011;8:e1000419.

20 Nandi A, Glymour MM, Subramanian SV. Association among socioeconomic status, health behaviors, and all-cause mortality in the United States. *Epidemiology* 2014;25:170–7.

21 Daly MC, Duncan GJ, McDonough P, *et al*. Optimal indicators of socioeconomic status for health research. *Am J Public Health* 2002;92:1151–7.

22 Attanasio OP, Emmerson C. Mortality, health status, and wealth. *J Eur Econ Assoc* 2003;1:821–50.

23 Shaw BA, McGeever K, Vasquez E, *et al*. Socioeconomic inequalities in health after age 50: are health risk behaviors to blame? *Soc Sci Med* 2014;101:52–60.

24 Feinglass J, Lin S, Thompson J, *et al*. Baseline health, socioeconomic status, and 10-year mortality among older middle-aged Americans: findings from the Health and Retirement Study, 1992 2002. *J Gerontol B Psychol Sci Soc Sci* 2007;62:S209–17.

25 Adena M, Myck M. Poverty and transitions in health in later life. *Soc Sci Med* 2014;116:202–10.

26 Banks J, Muriel A, Smith JP. Disease prevalence, disease incidence, and mortality in the United States and in England. *Demography* 2010;47(Suppl):S211–31.

27 Hoffmann R. Socioeconomic inequalities in old-age mortality: a comparison of Denmark and the USA. *Soc Sci Med* 2011;72:1986–92.

28 Hurd M, McFadden D, Merrill A. Predictors of mortality among the elderly. NBER Working Paper No. 7440. December 1999. www.nber.org/papers/w7440 (last accessed Oct 2015).

29 Laaksonen M, Martikainen P, Nihtilä E, *et al*. Home ownership and mortality: a register-based follow-up study of 300,000 Finns. *J Epidemiol Community Health* 2008;62:293–7.

30 Bond Huie SA, Krueger PM, Rogers RG, *et al*. Wealth, race, and mortality*. *Soc Sci Q* 2003;84:667–84.