The Role of Cognitive Ability (Intelligence) in Explaining the Association between Socioeconomic Position and Health: Evidence from the Whitehall II Prospective Cohort Study

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Associations among cognitive ability, socioeconomic position, and health have been interpreted to imply that cognitive ability could explain social inequalities in health. The authors test this hypothesis by examining three questions: Is cognitive ability related to health? To what extent does it explain social inequalities in health? Do measures of socioeconomic position and cognitive ability have independent associations with health? Relative indices of inequality were used to estimate associations, using data from the Whitehall II study (baseline, 1985–1988), a British prospective cohort study (4,158 men and 1,680 women). Cognitive ability was significantly related to coronary heart disease, physical functioning, and self-rated health in both sexes and additionally to mental functioning in men. It explained some of the relation between socioeconomic position and health: 17% for coronary heart disease, 33% for physical functioning, 12% for mental functioning, and 39% for self-rated health. In analysis simultaneously adjusted for all measures of socioeconomic position, cognitive ability retained an independent association only with physical functioning in women. These results suggest that, although cognitive ability is related to health, it does not explain social inequalities in health.

cognition; cohort studies; intelligence; socioeconomic factors

Social inequalities in health and mortality in industrialized countries have been widely reported (1–5). Primarily two sets of explanations have been advanced to account for them. The first set of explanations can be classified under the broad umbrella of the "social causation hypothesis" (5, 6), where factors linked to socioeconomic position are seen to cause poor health. The second set of explanations falls under the "selection hypothesis." One version of this hypothesis is the "direct selection" explanation, which proposes that poor health in childhood and adolescence leads to poor adult socioeconomic position (7, 8), with the causal direction here being from health to socioeconomic position. A more commonly held version of this hypothesis is "indirect selection," where some quality of the individual is believed to lead to both better socioeconomic position and better health (9, 10). Thus, a personality characteristic, genetic trait, or intelligence could determine both socioeconomic position and health. Out of the above, it is intelligence (or cognitive ability) that has received much research attention recently.

The terms "cognitive ability" and "intelligence" are mostly used interchangeably, although the former appears to be more frequently used in the epidemiologic literature and the latter in the psychological literature. Cognitive psychologists have disagreed on the exact nature of intelligence for over a hundred years, with some favoring one general construct underlying all intelligence and others believing in multiple factors (11). Research into the links between cognitive ability and health has focused on the role played by general intelligence (12–15). A group of 52

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experts defined it as "... a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience" (16, p. 13).

Interest in the relation between cognitive ability and health is driven by two different strands of research. The first comes from research into aging, examining the links between cognitive ability and survival. Many studies have found poor cognitive ability in old age to be a strong predictor of mortality (17–24). The causal pathways linking cognition to mortality remain unclear, although it has been suggested that an accelerated decline in cognitive function is an indicator of disease or accelerated biologic aging and, thus, related to mortality (17, 24, 25). As socioeconomic circumstances are known to shape cognitive development (26), it is also possible that cognitive ability in old age is a marker of accumulated socioeconomic advantage or disadvantage.

The paper by O'Toole and Stankov (27) in 1992 showing an intelligence test taken at army recruitment to predict midlife mortality in the Australian Veterans Health Study is the second source of interest in the link between intelligence and health. More recently, studies have linked cognitive ability in childhood to adult morbidity and mortality (15, 28–30). On the basis of these results, Gottfredson (13) has proposed that intelligence is the "fundamental cause" of social inequalities in health. Cognitive ability or more precisely the general intelligence factor is seen to lie behind both socioeconomic achievement and health (13). Gottfredson (13) and Gottfredson and Deary (14) have argued that technologic advances in modern societies make cognitive competence increasingly important for health. They propose that inadequate health self-care is the principal mechanism by which intelligence is related to social inequalities in health.

In this paper, we examine the links among cognitive ability, different measures of socioeconomic position, and health in midlife with a view to addressing the following questions:

1. Is cognitive ability related to different health outcomes in men and women?
2. To what extent does cognition explain social inequalities in health?
3. Do measures of socioeconomic position and cognitive ability have independent associations with health?

MATERIALS AND METHODS

The Whitehall II study was established in 1985 as a longitudinal study to examine the socioeconomic gradient in health and disease among 10,308 civil servants (6,895 men and 3,413 women) (31). All civil servants aged 35–55 years in 20 London-based departments were invited to participate by letter, and 73 percent agreed. The true response rate is likely to be higher, as approximately 4 percent of those on the provided list of employees had moved before the study began and thus were ineligible for inclusion. Baseline examination (phase 1) took place during

1985–1988 and involved a clinical examination and a self-administered questionnaire containing sections on demographic characteristics, health, lifestyle factors, work characteristics, social support, and life events. Clinical examination included measures of blood pressure, anthropometry, biochemical measurements, neuroendocrine function, and subclinical markers of cardiovascular disease. Subsequent phases of data collection have alternated between postal questionnaire alone and postal questionnaire accompanied by a clinical examination. Since baseline, five phases of data collection have been completed, with the most recent phase (phase 6) completed in 2001. The University College London ethics committee approved the study.

Risk factors, including socioeconomic position (four temporally distinct measures), and cognitive ability

Childhood socioeconomic position, earliest of the socioeconomic position measures, was assessed with a latent variable made up of two measures: father's social class and socioeconomic circumstances in childhood. Father's social class was assessed using the Registrar General's Social Class classification. In order to assess socioeconomic circumstances in childhood, respondents were asked to recall family conditions before they were 16 years of age. A four-item scale was used: father/mother unemployed when they wanted to be working, family had continuing financial problems, family did not have an inside toilet, and family did not have a car. Participants responded either "yes" or "no," and the "yes" responses were summed so that a high score indicated poor socioeconomic circumstances in childhood. Principal component analysis on the two measures of childhood socioeconomic position revealed one factor explaining 68.2 percent of the variance.

Education was measured as the highest level of education achieved, with the respondent choosing one of 11 categories. This was regrouped into five standard hierarchical levels: 1) no formal education, 2) lower secondary education, 3) higher secondary education, 4) degree, and 5) higher degree.

Occupational position was the British civil service grade of employment at phase 1. Employment grade ranges from 1 to 6, with grade 1 representing the highest level and grade 6 the lowest. People in different grades differ with respect to salary, social status, and level of responsibility.

Household wealth at phase 5 (1997–1999), the most recent measure of socioeconomic position, was measured using a question where respondents were asked to assess their total assets ("amount of money the respondent would have if she/he cashed in all household assets—house, car, caravan, boat, jewelry—and paid off all the debts"). The six categories measuring household wealth ranged from "less than £4,999" to "more than £500,000."

Cognitive ability (*intelligence*) was assessed in the analysis by a measure of fluid intelligence (Alice Heim 4, part I (AH 4-I)), seen to be isomorphic with general intelligence (32). The AH 4-I is composed of a series of 65 items: 32 verbal and 33 mathematical reasoning items of increasing difficulty (33). This is a test of inductive reasoning that measures the ability to identify patterns and to infer principles

and rules. Cognitive testing was introduced to the Whitehall study midway through phase 3, and consequently cognitive data are available on 40 percent of the available sample at phase 3 and on the entire sample at phase 5. In the analyses reported here, cognitive data are drawn from phase 5. As general intelligence is seen to be a trait that is stable from infancy into middle age (32, 34), our use of this measure from phase 5 is not problematic. The correlation between phases 3 and 5 of the AH 4-I measure, on the smaller sample on which it is available ($n = 2,556$), is 0.85 ($p < 0.0001$), further demonstrating the stability at this age of this construct.

Health outcomes assessed at phase 5 (1997–1999)

Coronary heart disease consisted of fatal coronary heart disease or incidence of nonfatal myocardial infarction or angina between *phases 1 and 5*. A total of 10,300 (99.9 percent) participants were "flagged" at the National Health Service Central Registry, providing information on date and cause of death. Coronary death was indicated by *International Classification of Diseases*, Ninth Revision, codes 410–414 (35). Potential nonfatal myocardial infarction and angina events were ascertained by questionnaire items on chest pain (the World Health Organization Rose Questionnaire) (36), treatment (nitrates or revascularization), recall of a doctor's diagnosis on a questionnaire item at phases 1–5, and investigation (exercise electrocardiography, stress imaging, or angiography). The latter were verified against clinical records. Twelve-lead resting electrocardiograms (digital electrocardiograph; Siemens Mingorec, Erlington, Germany) were performed at study phases 1, 3, and 5 and classified according to the Minnesota code (36, 37). Two independent trained coders carried out the classification of myocardial infarction and angina, with adjudication by a third coder in the (rare) event of disagreement.

Health Functioning was assessed using the Short Form 36 General Health Survey scales (38). The Short Form 36 is a 36-item questionnaire that covers issues relating to physical, psychological, and social functioning. It is coded into eight scales: physical functioning, social functioning, role limitations due to physical problems, role limitations due to emotional problems, vitality, bodily pain, general health perception, and general mental health. These eight scales of the Short Form 36 can be summarized into physical and mental components scores using factor analysis (39, 40). Poor health functioning was indicated by being in the worst quintile for physical and mental components scores.

Minor psychiatric morbidity was assessed at *phase 5* using the General Health Questionnaire. The General Health Questionnaire is a 30-item screening questionnaire for minor psychiatric disorders and is suitable for use in general population samples (41). A threshold of 4/5 on the General Health Questionnaire was chosen; all those scoring 0–4 were considered noncases and those scoring ≥ 5 were considered cases.

Self-rated health was assessed via the following question: "In general, would you say your health is excellent/very good/good/fair/poor?" For the purposes of this study,

participants reporting the two poorest levels of health were categorized as having "poor" perceived general health.

Statistical methods

The relative index of inequality (RII) was used to examine the relation between socioeconomic position and health outcomes (42). The RII is a regression-based summary measure widely used in social inequalities research because it takes into account the size of all the social groups in a socioeconomic hierarchy (43, 44). This index is calculated by ranking the socioeconomic categories on a scale from the lowest, which is 0, to the highest, which is 1. Each category covers a range on the scale proportional to its population size and is given a value on the scale corresponding to the midpoint of its range. The morbidity rate of the socioeconomic position groups is then regressed on this measure of their relative position. The RII resembles relative risk in that it compares the health of the extremes of the social distribution, but it is estimated using the data on all social groups and is weighted to account for the size of social groups. The RII is interpreted as the ratio of the morbidity of the most disadvantaged to the most advantaged. Thus, if the index is 1.5, then the morbidity rate of the most disadvantaged is 1.5 times as high as that of the most advantaged; an RII of 1.00 would indicate equal morbidity across the socioeconomic hierarchy.

We used the RII to first assess the magnitude of the association between cognitive ability and the health outcomes. The second set of analyses examined the relation between different indicators of socioeconomic position and health and then examined the extent to which these relations could be explained by cognition. The first step here was to calculate RIIs showing the age-adjusted relation between each measure of socioeconomic position and ill health. The next step introduced cognitive ability to the model with age and socioeconomic position, its contribution being expressed by the percentage reduction in RII (percent reduction $= (RII_{\text{socioeconomic position, controlling for age}} - RII_{\text{socioeconomic position, controlling for age and cognitive ability}})/(RII_{\text{socioeconomic position, controlling for age}} - 1) \times 100)$. The final set of analyses consisted of simultaneously entering age, socioeconomic position, and cognitive ability as predictors. All analyses were carried out separately for men and women.

RESULTS

A total of 10,308 individuals were examined at baseline (phase 1, 1985–1988); 355 participants died between phases 1 and 5 (mean follow-up: 11 years). At phase 5 (1997–1999), complete information on all the variables included in this study was available on 5,838 (4,158 men and 1,680 women) individuals. Missing data were influenced by age ($p = 0.001$) and employment grade ($p = 0.001$) but not by sex ($p = 0.61$), and the attrition rate was higher among older respondents and low-socioeconomic groups. The average age of participants at phases 1 and 5 was 44.45 years (standard deviation $= 6.05$) and 55.86 years (standard

TABLE 1. Correlation among risk factors and frequency of poor health at phase 5 (1997–1999) of the Whitehall II study, United Kingdom

	Pearson's correlations	
	Men	Women
Cognition and childhood socioeconomic position	0.13*	0.29*
Cognition and education	0.32*	0.53*
Cognition and employment grade	0.50*	0.62*
Cognition and household wealth	0.21*	0.32*

	Frequency of poor health			
	Men		Women	
	%†	No.‡	%	No.
Incident coronary heart disease	11.9	496	16.1	270
Physical component score§	19.8	822	19.3	324
Mental component score§	19.8	822	19.3	324
General Health Questionnaire¶	19.6	815	25.5	429
Self-rated health#	11.0	458	16.9	283

* Correlation significant at $p < 0.0001$.

† Frequency percentages were derived by number with poor health divided by total number as defined below.

‡ Total numbers exclude persons with missing data. Complete data were available for 4,158 men and 1,680 women.

§ Lowest quintile of score derived from the Short Form 36 General Health Survey.

¶ A score of ≥ 5 on the General Health Questionnaire.

Self-rated health = the two poorest levels of health on a five-point scale.

TABLE 2. Age-adjusted association between cognitive ability and ill health at phase 5 (1997–1999) of the Whitehall II study, United Kingdom

Health outcomes	Men		Women	
	RII†	95% CI†	RII	95% CI
Incident coronary heart disease	1.68	1.20, 2.35*	1.76	1.08, 2.87*
Physical component score‡	1.46	1.11, 1.91*	2.81	1.76, 4.48*
Mental component score‡	1.57	1.19, 2.06*	1.42	0.90, 2.25
General Health Questionnaire§	1.20	0.91, 1.57	1.10	0.73, 1.68
Self-rated health¶	2.49	1.76, 3.53*	3.58	2.20, 5.82*

* Statistically significant associations at $p = 0.05$.

† RII, relative index of inequality; CI, confidence interval.

‡ Lowest quintile of score derived from the Short Form 36 General Health Survey.

§ A score of ≥ 5 on the General Health Questionnaire.

¶ Self-rated health = the two poorest levels of health on a five-point scale.

deviation = 6.06), respectively. Correlation analysis shows cognitive ability to be significantly related to all measures of socioeconomic position; the correlation with employment grade was the strongest, and that with childhood socioeconomic position was the weakest (table 1). Table 1 also shows the number of individuals who reported poor health on the health indicators used in this study.

The age-adjusted associations (table 2) between cognitive ability and different measures of ill health reveal the association to be strongest with self-rated health in both men (RII = 2.49) and women (RII = 3.58). Minor psychiatric morbidity as measured by the General Health Questionnaire was not significantly associated with cognitive ability.

Table 3 shows both the age-adjusted relation between socioeconomic position and ill health and these associations after adjustment for cognitive ability. All four measures of

socioeconomic position are significantly related to incident coronary heart disease, physical functioning (physical component score), and self-rated health. Childhood socioeconomic position and household wealth have significant effects on mental health, as measured by the mental component score and General Health Questionnaire. Cognitive ability explains between 9 and 33 percent of the relation between socioeconomic position and coronary heart disease, between 17 and 38 percent for physical functioning, between 9 and 22 percent for mental functioning (mental component score), between 1 and 4 percent for the General Health Questionnaire, and between 16 and 69 percent for self-rated health.

In women (table 4), childhood socioeconomic position was significantly associated with the mental component score, General Health Questionnaire, and self-rated health, but only the relation with the General Health Questionnaire survived adjustment for cognitive ability. Education was not significantly associated with any of the health outcomes examined here. Employment grade was associated with coronary heart disease, physical component score, and self-rated health; 16, 58, and 59 percent of these relations, respectively, were explained by cognitive ability. Household wealth was associated with all the health outcomes examined, and cognitive ability explained up to 41 percent of this relation.

In the final analysis (table 5), all the predictors were mutually adjusted for each other. Household wealth remained significantly associated with all the health outcomes in both men and women. Childhood socioeconomic position in men and grade in women had independent associations with coronary heart disease. Employment grade in men and cognitive ability in women had independent effects on physical functioning (physical component score). Childhood socioeconomic position was also independently associated

TABLE 3. Association between measures of socioeconomic position and ill health among men at phase 5 (1997–1999) of the Whitehall II study, United Kingdom

Health outcomes and risk factors	Adjusted for age		Adjusted for age and cognitive ability (AH 4-I†)		
	RII†	95% CI†	RII	95% CI	% reduction in RII‡,§
Incident coronary heart disease					
Childhood socioeconomic position	2.05	1.43, 2.93*	1.95	1.36, 2.81*	9
Education	1.80	1.27, 2.56*	1.55	1.08, 2.23*	31
Employment grade	2.00	1.43, 2.79*	1.67	1.12, 2.48*	33
Household wealth	3.00	1.96, 4.58*	2.74	1.76, 4.26*	13
Physical component score¶					
Childhood socioeconomic position	1.36	1.03, 1.81*	1.30	0.98, 1.74	17
Education	1.34	1.01, 1.78*	1.21	0.90, 1.62	38
Employment grade	1.85	1.41, 2.44*	1.63	1.18, 2.25*	26
Household wealth	1.93	1.38, 2.72*	1.77	1.25, 2.52*	17
Mental component score¶					
Childhood socioeconomic position	1.76	1.32, 2.35*	1.69	1.26, 2.26*	9
Education	0.94	0.70, 1.24	0.76	0.57, 1.03	NA†
Employment grade	2.03	1.53, 2.71*	1.66	1.19, 2.32*	22
Household wealth	4.16	2.98, 5.81*	3.85	2.73, 5.44*	10
General Health Questionnaire#					
Childhood socioeconomic position	1.54	1.15, 2.05*	1.52	1.14, 2.03*	4
Education	1.01	0.76, 1.34	0.93	0.69, 1.25	NA
Employment grade	1.25	0.94, 1.66	1.10	0.79, 1.53	NA
Household wealth	2.39	1.71, 3.34*	2.37	1.68, 3.35*	1
Self-rated health††					
Childhood socioeconomic position	1.85	1.28, 2.67*	1.69	1.17, 2.44*	19
Education	1.51	1.05, 2.17*	1.16	0.80, 1.70	69
Employment grade	2.77	1.94, 3.97*	1.89	1.24, 2.87*	34
Household wealth	4.66	3.08, 7.05*	3.77	2.45, 5.79*	24

  * Statistically significant associations at $p = 0.05$.

  † AH 4-I, a measure of fluid intelligence composed of 32 verbal and 33 mathematical reasoning items (Alice Heim 4, part I); RII, relative index of inequality; CI, confidence interval; NA, not applicable.

  ‡ Percent reduction in RII = ($RII_{socioeconomic position, controlling for age}$ − $RII_{socioeconomic position, controlling for age and cognitive ability}$)/ ($RII_{socioeconomic position, controlling for age}$ − 1) × 100.

  § The calculation of percent reduction in RII was restricted to statistically significant associations between socioeconomic position and health.

  ¶ Lowest quintile of score derived from the Short Form 36 General Health Survey.

  # A score of ≥5 on the General Health Questionnaire.

  †† Self-rated health = the two poorest levels of health on a five-point scale.

with mental functioning in men and self-rated health in women. Controlling for other measures of socioeconomic position and cognition led higher education to have an inverse association with the mental component score in men and with coronary heart disease, the physical component score, the mental component score, and self-rated health in women.

DISCUSSION

This paper presents three key findings. First, cognitive ability is significantly related to health outcomes in men and

women. Second, cognitive ability explains some of the association between socioeconomic position and different health outcomes, but it is not likely to be the fundamental cause of social inequalities in health. The percentage reductions in the RIIs show the extent to which general intelligence explains social inequalities in health. This value varies with the measure of socioeconomic position used, by the health outcome under consideration, and by gender. Third, only household wealth has independent associations, in men and women, with all health outcomes examined. Cognitive ability has an independent effect only on physical functioning in women.

TABLE 4.   Association between measures of socioeconomic position and ill health among women at phase 5 (1997–1999) of the Whitehall II study, United Kingdom

Health outcomes and risk factors	Adjusted for age		Adjusted for age and cognitive ability (AH 4-I†)		
	RII†	95% CI†	RII	95% CI	% reduction in RII‡,§
Incident coronary heart disease					
Childhood socioeconomic position	1.64	0.98, 2.73	1.49	0.88, 2.53	NA†
Education	0.91	0.54, 1.54	0.69	0.38, 1.25	NA
Employment grade	2.12	1.29, 3.50*	1.94	1.04, 3.63*	16
Household wealth	2.31	1.37, 3.92*	2.31	1.32, 4.05*	0
Physical component score¶					
Childhood socioeconomic position	1.46	0.91, 2.36	1.24	0.76, 2.04	NA
Education	1.11	0.68, 1.80	0.62	0.36, 1.08	NA
Employment grade	2.58	1.61, 4.12*	1.67	0.93, 3.02	58
Household wealth	2.37	1.46, 3.84*	1.81	1.08, 3.03*	41
Mental component score¶					
Childhood socioeconomic position	1.62	1.01, 2.59*	1.51	0.94, 2.45	18
Education	0.92	0.57, 1.49	0.74	0.43, 1.29	NA
Employment grade	1.37	0.87, 2.17	1.19	0.67, 2.15	NA
Household wealth	2.46	1.52, 3.97*	2.43	1.46, 4.04*	2
General Health Questionnaire#					
Childhood socioeconomic position	1.64	1.07, 2.51*	1.63	1.05, 2.53*	2
Education	0.95	0.62, 1.48	0.89	0.54, 1.48	NA
Employment grade	1.12	0.74, 1.69	1.12	0.66, 1.90	NA
Household wealth	1.95	1.26, 3.01*	2.02	1.28, 3.21*	–7
Self-rated health††					
Childhood socioeconomic position	2.52	1.52, 4.19*	1.99	1.17, 3.36*	35
Education	1.32	0.79, 2.22	0.72	0.40, 1.29	NA
Employment grade	3.46	2.10, 5.69*	1.96	1.05, 3.67*	59
Household wealth	3.62	2.17, 6.04*	2.81	1.63, 4.83*	31

  * Statistically significant associations at $p = 0.05$.
  † AH 4-I, a measure of fluid intelligence composed of 32 verbal and 33 mathematical reasoning items (Alice Heim 4, part I); RII, relative index of inequality; CI, confidence interval; NA, not applicable.
  ‡ Percent reduction in RII = (RII$_{socioeconomic position, controlling for age}$ − RII$_{socioeconomic position, controlling for age and cognitive ability}$)/(RII$_{socioeconomic position, controlling for age}$ − 1) × 100.
  § The calculation of percent reduction in RII was restricted to statistically significant associations between socioeconomic position and health.
  ¶ Lowest quintile of score derived from the Short Form 36 General Health Survey.
  # A score of ≥5 on the General Health Questionnaire.
  †† Self-rated health = the two poorest levels of health on a five-point scale.

Cognitive ability does not, in any of our analyses, fully explain the relation between socioeconomic position and health. The mean reduction in RII for childhood socioeconomic position was 12 percent in men and 18 percent in women; for education, 46 percent in men; for employment grade, 29 percent in men and 44 percent in women; and for household wealth, 13 percent in men and women. Several of the relations between socioeconomic position and health survive adjustment for cognitive ability. All significant relations between household wealth and health outcomes remain significant after the inclusion of cognitive ability in the model. The same is true for employment grade in men; among women, two of three significant associations with employment grade remain after adjustment for cognitive ability. Childhood socioeconomic position in men continues to be significantly associated with four of five of the health outcomes after adjustment for cognitive ability. These results suggest that different measures of socioeconomic position are not interchangeable, and they are not proxies for mental resources.

The final set of analyses assesses the effects of the predictors mutually adjusted for each other. The only

TABLE 5.   Measures of socioeconomic position and cognitive ability (mutually adjusted) as predictors of ill health at phase 5 (1997–1999) of the Whitehall II study, United Kingdom

Health outcomes and risk factors	Men		Women	
	RII†	95% CI†	RII	95% CI
Incident coronary heart disease				
Childhood socioeconomic position	1.63	1.12, 2.37*	1.49	0.81, 2.74
Cognition	1.04	0.68, 1.59	0.96	0.45, 2.03
Education	1.23	0.80, 1.89	0.24	0.11, 0.51*
Employment grade	1.05	0.65, 1.69	2.48	1.08, 5.67*
Household wealth	2.58	1.56, 4.27*	2.59	1.34, 5.00*
Physical component score‡				
Childhood socioeconomic position	1.15	0.86, 1.56	1.28	0.73, 2.23
Cognition	0.93	0.66, 1.30	2.08	1.03, 4.23*
Education	1.00	0.71, 1.42	0.47	0.23, 0.95*
Employment grade	1.46	1.00, 2.16*	1.51	0.70, 3.25
Household wealth	1.63	1.09, 2.43*	1.89	1.02, 3.47*
Mental component score‡				
Childhood socioeconomic position	1.61	1.19, 2.18*	1.46	0.84, 2.52
Cognition	0.95	0.68, −1.34	1.29	0.65, 2.58
Education	0.60	0.42, 0.86*	0.48	0.24, 0.96*
Employment grade	1.44	0.96, 2.17	1.04	0.48, 2.25
Household wealth	3.51	2.37, 5.20*	2.85	1.57, 5.16*
General Health Questionnaire§				
Childhood socioeconomic position	1.34	0.99, 1.81	1.50	0.92, 2.47
Cognition	0.92	0.66, 1.30	0.83	0.44, 1.55
Education	0.91	0.64, 1.30	0.78	0.41, 1.49
Employment grade	0.92	0.61, 1.38	0.91	0.45, 1.83
Household wealth	2.37	1.60, 3.52*	1.88	1.09, 3.23*
Self-rated health¶				
Childhood socioeconomic position	1.45	0.98, 2.13	2.17	1.18, 3.96*
Cognition	1.27	0.82, 1.96	1.97	0.94, 4.15
Education	0.88	0.56, 1.38	0.34	0.16, 0.71*
Employment grade	1.38	0.82, 2.32	2.02	0.88, 4.62
Household wealth	3.75	2.28, 6.15*	2.22	1.17, 4.21*

* Statistically significant associations at $p = 0.05$.
† RII, relative index of inequality, adjusted for age; CI, confidence interval.
‡ Lowest quintile of score derived from the Short Form 36 General Health Survey.
§ A score of ≥5 on the General Health Questionnaire.
¶ Self-rated health = the two poorest levels of health on a five-point scale.

significant effect of cognitive ability was on physical functioning in women. None of the other associations was independent of socioeconomic position. On the other hand, household wealth was significantly associated with all health outcomes, perhaps because it is a cumulative measure reflecting aspects of socioeconomic circumstances across the life course. The significant effects associated with education are counterintuitive, as they suggest that high educational achievement is predictive of poorer health. This has been previously examined in the

Whitehall II study data. It is plausible that better-educated individuals have poorer health than those less educated *given that* they have achieved the same wealth and occupational status (45). In white collar professions such as the British civil service, education is strongly linked to occupational attainment and mobility, and discrepancies between the two are associated with poor health.

It has been hypothesized that income, occupation, and education would have successively stronger associations

with health because of their increasing correlation with general intelligence (13, 14). Our results do not support this proposition. Education was not significantly associated with any of the health outcomes in women, and it was not associated with mental functioning (mental component score) and minor psychiatric disorder (General Health Questionnaire) among men. Furthermore, among the different measures of socioeconomic position, it has the weakest relation with all the health outcomes examined. Results in tables 3 and 4 clearly show that the extent of social inequalities in health varies by the measure of social position used. Household wealth has the strongest relation with health outcomes for both sexes, except for physical functioning in women, where employment grade shows a stronger association. It is likely that different measures of socioeconomic position represent different facets of social position and are differently related to health outcomes (46, 47).

The interrelation among socioeconomic position, cognitive ability (intelligence), and health is an important question and increasingly manifest in the social inequalities literature. The view, proposed by Gottfredson (13), that intelligence is the fundamental cause of social inequalities sees cognitive ability to be the driving force behind both socioeconomic attainment and health. The alternate view is that, although socioeconomic position and cognitive ability are related to each other, social inequalities in health cannot be explained by group differences in intelligence. Our results show the constructs of both health and socioeconomic position to be multifaceted; not all health outcomes show the same social patterning, and not all measures of socioeconomic position are similarly related to health.

Recent work on cognitive ability (intelligence) highlights its importance to health. Gottfredson (13) and Gottfredson and Deary (14) have argued that effective self-care is the primary mechanism through which intelligence influences health. Intelligence is seen to promote faster and more complete learning, resulting in better preventive self-care and better compliance with medication instructions. Whalley and Deary (15) have proposed four mechanisms to explain the association between childhood intelligence and mortality. These are childhood intelligence as a record of bodily insults, as an indictor of system integrity, as related to healthy behaviors, and as a predictor of entry into safer environments. We found intelligence to have some independent association with health. Given the association between socioeconomic position and intelligence, it is likely that some of the pathways to health are shared. Further research is required to clarify the shared and independent pathways. This should also help to explain why cognitive ability has a differential impact on different health outcomes, strongest here with self-rated health and weakest with minor psychiatric disorder.

A number of limitations should be noted. First, data here are from white collar civil service employees and cannot be assumed to represent general populations. However, participants cover a wide range of the socioeconomic spectrum, with annual full-time salaries in 1995 ranging from £4,995 to £150,000. Second, cognitive ability in this study was assessed in midlife, and the variable used is a proxy for intelligence. However, this is unlikely to affect our results as it has been argued that general intelligence is a stable, individual trait

and isomorphic with the measure used in these analyses (32). Finally, results are affected by higher rates of missing data among the older and lower-grade participants, leading to underestimation of the effects of socioeconomic position.

In conclusion, our results show cognitive ability to be important for health outcomes but not to be driving social inequalities in health. The pathways linking education and intelligence to health appear to be similar, although education is not a particularly strong correlate of health in these data. Social inequalities are multifaceted; inequalities linked to educational disadvantage represent only one aspect of inequality. As education is closely linked with cognitive ability, it is not surprising that a large proportion of the relation between education and health, when it exists, is explained by cognitive ability. However, other measures of socioeconomic position, employment grade and household wealth in particular, are associated with health independently of cognitive ability. A major challenge for future research is to identify the mechanism(s) through which intelligence influences health.

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