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Original Contribution

Socioeconomic Status, Structural and Functional Measures of Social Support, and Mortality

The British Whitehall II Cohort Study, 1985–2009

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The authors examined the associations of social support with socioeconomic status (SES) and with mortality, as well as how SES differences in social support might account for SES differences in mortality. Analyses were based on 9,333 participants from the British Whitehall II Study cohort, a longitudinal cohort established in 1985 among London-based civil servants who were 35–55 years of age at baseline. SES was assessed using participant's employment grades at baseline. Social support was assessed 3 times in the 24.4-year period during which participants were monitored for death. In men, marital status, and to a lesser extent network score (but not low perceived support or high negative aspects of close relationships), predicted both all-cause and cardiovascular mortality. Measures of social support were not associated with cancer mortality. Men in the lowest SES category had an increased risk of death compared with those in the highest category (for all-cause mortality, hazard ratio = 1.59, 95% confidence interval: 1.21, 2.08; for cardiovascular mortality, hazard ratio = 2.48, 95% confidence interval: 1.55, 3.92). Network score and marital status combined explained 27% (95% confidence interval: 14, 43) and 29% (95% confidence interval: 17, 52) of the associations between SES and all-cause and cardiovascular mortality, respectively. In women, there was no consistent association between social support indicators and mortality. The present study suggests that in men, social isolation is not only an important risk factor for mortality but is also likely to contribute to differences in mortality by SES.

cohort; longitudinal; mortality; social class; social support

Abbreviations: CI, confidence interval; CVD, cardiovascular disease; HR, hazard ratio; SES, socioeconomic status.

Since the late 1970s, evidence has accumulated about the importance of social support in relation to mortality (1–7). A much-cited review from the late 1980s (8) compared the strength of the association between social relationships and health to that of cigarette smoking and health. Subsequent observational studies have shown that lack of social support has adverse effects on mortality rates (9, 10) and a variety of other health outcomes, including coronary heart disease (11), mental health (12, 13), self-rated health (14), and prognosis after myocardial infarction (15, 16).

Structural/quantitative measures of social support, such as social network size and participation in group activities, have often been used to assess levels of social support (1, 2, 5, 6, 9, 17). A number of studies have also focused on the relational content of social interactions using functional measures (3, 7, 15), such as emotional or instrumental support, or negative aspects of close relationships (18–20).

Measures of social support have been shown to be associated with socioeconomic status (SES), in the sense that individuals in higher socioeconomic groups are more likely to be married, have more friends, and report higher levels of social support (21, 22). This has led researchers to consider the different availability of social support between socioeconomic groups as one of the mechanisms through which socioeconomic circumstances "get under the skin" to influence health (11, 22–25). However, few studies have attempted to evaluate

the contribution of social support to socioeconomic differences in health, and those that have done so have produced inconsistent results (24).

In the present study, we used data from the Whitehall II Study to examine the extent to which a number of structural and functional measures of social support are related to SES, as well as the extent to which they are associated with all-cause and cause-specific mortality. We additionally examined the contribution of these factors to socioeconomic differences in all-cause and cardiovascular mortality rates.

MATERIALS AND METHODS

Study population

The Whitehall II Study was established in 1985 among 10,308 London-based civil servants (6,895 men and 3,413 women) who were 35–55 years of age (26). Baseline examination (phase 1) took place during 1985–1988 and involved a clinical examination and a self-administered questionnaire that contained sections on demographic characteristics, health, lifestyle factors, work characteristics, social support, and life events.

Socioeconomic status

SES was assessed using occupational position at baseline (phase 1). This information was obtained by asking the participants to give their civil service grade title (27, 28). Participants were then classified using the civil service employment grade classification and grouped into 3 grade categories: high (administrative), intermediate (professional or executive), and low (clerical or support). This measure is a comprehensive marker of socioeconomic circumstances and is related to salary, level of responsibility at work, and educational level (27, 29).

Social support

Comprehensive measurements of functional and structural aspects of social support were available in phase 2 (1989–1990), phase 5 (1997–1999), and phase 7 (2002–2004) of the study. See the Web Appendix (available at http://aje.oxfordjournals.org) for examples of the questionnaires used.

Functional measures of social support. Using the Close Persons Questionnaire (30), we assessed 3 functional measures of social support: confiding/emotional support, practical support, and negative aspects of close relationships. The questionnaire assessed the support received from the person nominated by the participant as the person to whom he or she is closest. Confiding/emotional support measures (7 items) included wanting to confide, confiding, sharing interests, boosting self-esteem, and reciprocity. Practical support (4 items) was a measure of practical help received and negative aspects of close relationships (4 items) measured adverse exchanges and conflicts within a relationship. Each item was evaluated on a 4-point Likert scale, with higher scores indicating higher support or greater negative aspects. The Likert-scaled responses for each social support scale item were summed and then grouped into quartiles. The Cronbach α for the scales was 0.63 for negative aspects of close relationships, 0.85 for confiding/emotional support, and 0.82 for practical support. Test-retest reliability over a 4-week interval was 0.72 for negative close relationships, 0.71 for practical support, and 0.88 for confiding/emotional support (30).

Structural measures of social support. We used 2 structural measures: marital status and a measure of social network. The social network measure was obtained from questions 1) on the frequency of contacts with relatives, friends, and colleagues and the frequency of participation in social or religious activities and 2) on the total number of relatives or friends seen once a month or more. The scaled responses were summed, and the overall number was divided into quartiles. Marital status was coded as married/cohabiting or never married, separated, divorced, and widowed combined. Because preliminary analyses revealed that only participants in the lowest quartile of social support (or highest quartile for negative aspects of relationships) were at higher risk for premature death, measures of social support were dichotomized and the lowest quartile (or highest quartile for negative aspects of relationships) was compared with the other 3 quartiles.

Missing data on social support. We used primarily phase 2 data rather than phase 1 data, as the social support questions were introduced into the study midway through phase 1. For missing data in phase 2 (between 16% and 18%, depending on the measure) we used data from phase 1. In phases 5 and 7, we applied multiple multivariate imputation based on sex, age, occupational grade, and social support or network score at the preceding phase to impute missing values for social support and network score. Missing data on marital status were replaced with data from the previous phase. At least 1 missing value was imputed for 28% of participants in phase 5 and 13% in phase 7.

Mortality

We successfully assessed mortality in 10,297 (99.9%) participants through the national mortality register kept by the National Health Services Central Registry, using the National Health Service identification number. Participants were followed from phase 1 until January 31, 2010, a total of 24.4 years (mean = 20.8 years). We examined all-cause mortality, cancer, and cardiovascular disease (CVD). Codes from the *International Classification of Diseases*, Ninth and Tenth Revisions, were used to define cancer (codes 140.0–209.9 from the Ninth Revision and codes C00–C97 from the Tenth Revision) and CVD (codes 390.0–458.9 from the Ninth Revision and codes I00–I99 from the Tenth Revision) mortality.

Statistical analysis

All analyses were performed separately in men and women. The association of SES with measures of social support was examined using age- and self-rated health-adjusted logistic regressions with SES entered as a 3-level categorical variable.

We examined the associations of each measure of social support, used as time-dependent variables, with all-cause, cardiovascular, and cancer (results not shown) mortality using age-adjusted Cox regressions. We subsequently introduced adjustment for SES and self-rated health. We then estimated hazard ratios and their 95% confidence intervals for the

association between SES and mortality. Because this association was not significant at conventional levels in women (for the lowest grade vs. the highest, age-adjusted hazard ratio (HR) = 1.34, 95% confidence interval (CI): 0.89, 2.01) and because there was no socioeconomic gradient in cancer mortality in this study (for lowest grade vs. the highest in men, age-adjusted HR = 1.18, 95% CI: 0.77, 1.81), further analysis involving SES and mortality were based only on men and restricted to all-cause and CVD mortality. These analyses examined the extent to which the social support measures explained the association of SES with all-cause mortality and with CVD mortality. As tests did not suggest a departure from a linear trend, we used the measure of SES as a continuous 3-level variable. The hazard ratio associated with a 1-unit change in SES was squared to yield the hazard in the lowest socioeconomic group versus that in the highest (a 2-unit change) under the assumption of linearity of the association between SES and mortality. We first adjusted the Cox regression model for age (model 1). Then, the association of SES with mortality was further adjusted for self-rated health (model 2). Subsequently, the social support items assessed longitudinally through the follow-up were first entered individually and then simultaneously into model 2. The contribution of social support to the association between SES and mortality was determined by the percentage reduction in the SES coefficient after inclusion of the indicator in question to model 2, using the following formula: $100 \times (\beta_{\text{model 2}} - \beta_{\text{model 2 + social support(s)}})/(\beta_{\text{model 2}})$. We finally calculated a 95% confidence interval around the percentage of attenuation using a bias-corrected accelerated bootstrap method with 2,000 resamplings.

In the Cox regression analyses, participants for whom we had complete data on all measures at all intervals preceding death or the end of follow-up (after imputation) were censored at their date of death or at the end of follow-up. The remaining participants were censored after imputation at the last date at which they had complete data on all measures for all preceding phases.

Measures of social support and self-rated health were assessed as time-dependent variables using the episode-splitting method. SES as assessed at baseline was used in all analyses, as allowing SES to vary over time would introduce reverse causation biases. The proportional hazard assumptions for Cox regression models were tested using Schoenfeld residuals and were found not to be violated (all P values ≥ 0.05).

RESULTS

A total of 976 participants were excluded from the analysis because of missing data on 1 or more measures of social support at baseline (965 participants) or because they were not followed-up for mortality (11 participants). The analysis was based on the remaining 9,333 participants (6,339 men and 2,994 women). Persons who were excluded tended to be from the lowest socioeconomic group at baseline ($P < 0.001$). For 9 participants, the cause of death was unknown, and they were therefore excluded from the cause-specific analyses.

Table 1 shows characteristics of the study population. In men, there was a marked social gradient in mortality risk, self-rated health, and all indicators of social support (all $P < 0.01$), such that men with higher SES had better health and a better social support profile. In women, there was no linear association between SES and mortality ($P = 0.162$). Women with a high SES reported low levels of practical support ($P = 0.002$) and were more likely to live alone ($P < 0.001$) but had higher network scores ($P < 0.001$).

Odds ratios showing the association between SES and social support are presented in Table 2. At baseline (phases 1 and 2), men in the lowest SES category were more likely to report less emotional support, more negative aspects of close relationships, and a low network score and were over 5 times more likely to be unmarried than were men in the highest SES category. In general, women in the highest SES category had a lower social support profile than did women in the lowest. The SES-social support association differed by sex for all indicators (all $P < 0.05$) except network score at baseline ($P = 0.14$) and negative aspects of close relationships at the last follow-up ($P = 0.15$).

Table 3 shows the association between indicators of social support and both all-cause and CVD mortality. For all-cause mortality in men, a low network score (HR = 1.27, 95% CI: 1.07, 1.52) and being unmarried were associated with a higher mortality risk (HR = 1.77, 95% CI: 1.45, 2.16). The association of network score with all-cause mortality was reduced to borderline significance after adjustment for SES and self-rated health (HR = 1.18, 95% CI: 0.99, 1.40), whereas there remained a 51% excess risk (HR = 1.51, 95% CI: 1.23, 1.86) of death for participants who were not married or cohabiting. Women who reported low levels of confiding/emotional support had a lower mortality risk in the model adjusted for SES and self-rated health. The structural measures of social support were not associated with mortality in women. In men, the SES-adjusted and self-rated health-adjusted associations of low network score (HR = 1.66, 95% CI: 1.22, 2.26) and living alone (HR = 2.16, 95% CI: 1.55, 3.03) with CVD mortality were stronger than were those observed for all-cause mortality. None of the measures of social support was related to cancer mortality (results not shown).

As only structural measures of social support were associated with both SES and mortality, we examined their contribution to the socioeconomic differences in all-cause and CVD mortality (Table 4) in men only because of the lack of associations in women. The age- and self-rated health-adjusted hazard ratio for mortality in the lowest SES group compared with the highest was 1.59 (95% CI: 1.21, 2.08) for all-cause mortality and 2.48 (95% CI: 1.56, 3.92) for CVD mortality. Overall, network score and marital status explained 27% (95% CI: 14, 43) of the association of SES with all-cause mortality and 29% (95% CI: 17, 52) of the association of SES with CVD mortality.

DISCUSSION

In the present study, we examined several indicators of social support and their association with SES and mortality, and we estimated their contribution to SES differences in all-cause and cardiovascular mortality rates. Our results show that in men, both structural and functional measures of social support are socially patterned, in that men with higher SES report better

Table 1. Baseline Characteristics of the Study Population, Whitehall II Study, 1985–2009

Characteristic	Occupational Position, Men (n = 6,339)									*P* Value
	High (n = 2,454; 38.7%)			Intermediate (n = 3,338; 52.7%)			Low (n = 547; 8.6%)			
	No. of Participants	%	Rate[a]	No. of Participants	%	Rate[a]	No. of Participants	%	Rate[a]	
Died	195	7.9	3.3	250	7.5	3.9	73	13.3	6.7	<0.001[b]
Death from cardiovascular disease	57	2.3	1.0	77	2.3	1.2	34	6.2	3.1	<0.001[b]
Death from cancer	92	3.7	1.6	106	3.2	1.7	19	3.5	1.7	0.439[b]
Low level of confiding/ emotional support[c]	531	21.6		855	25.6		165	30.2		<0.001[d]
Low level of practical support[c]	494	20.1		860	25.8		172	31.4		<0.001[d]
High level of negative aspects of close relationships[c]	730	29.8		1,108	33.2		224	41.0		<0.001[d]
Low network score[c]	658	26.8		1,004	30.1		181	33.1		0.002[d]
Not married/cohabiting	254	10.4		688	20.6		216	39.5		<0.001[d]
Poor self-rated health	60	2.4		136	4.0		40	7.3		<0.001[d]
	Occupational Position, Women (n = 2,994)									
	High (n = 343; 11.5%)			Intermediate (n = 1,210; 40.4%)			Low (n = 1441; 48.1%)			
	No. of Participants	%	Rate[c]	No. of Participants	%	Rate[c]	No. of Participants	%	Rate[c]	
Died	20	5.8	3.4	82	6.8	3.5	121	8.4	3.9	0.162[b]
Death from cardiovascular disease	0	0	0.0	13	1.1	0.5	31	2.2	1.0	0.004[b]
Death from cancer	13	3.8	2.2	52	4.3	2.3	63	4.4	2.1	0.962[b]
Low level of confiding/ emotional support[c]	76	22.2		244	20.2		272	18.9		0.350[d]
Low level of practical support[c]	124	36.2		455	37.6		449	31.2		0.002[d]
High level of negative aspects of close relationships[c]	110	32.0		375	31.0		498	34.6		0.140[d]
Low network score[c]	69	20.1		395	32.6		452	31.4		<0.001[d]
Not married/cohabiting	131	38.2		538	44.5		469	32.6		<0.001[d]
Poor self-rated health	12	3.5		92	7.6		114	7.9		0.020[d]

[a] Standardized mortality rate per 1,000 person-years.
[b] Test for linear trend across occupational groups.
[c] Categories were based on quartiles.
[d] Pearson's chi-squared test for heterogeneity across occupational groups.

social support. Furthermore, structural (small social network or not being married/cohabiting) but not functional aspects of support (lack of perceived support) predicted all-cause and cardiovascular mortality and explained approximately one-fourth of the association between SES and mortality. In women, those in the higher SES groups did not have better social support, and there was no consistent association between social support indicators and death.

Social support and mortality

Social support is hypothesized to affect health mainly by providing resources that can be used to avoid the risk of disease, minimize their consequences, or influence health-promoting or health-damaging behaviors (31). In addition, social support might have a direct impact on a range of physiologic systems, such as immune, neuroendocrine, and cardiovascular activity (10). In our study, poor social integration in men, particularly not being married or cohabiting, was an important predictor of all-cause and cardiovascular mortality. Most previous work on social support has been based on elderly or general populations in which individuals in "marginal" positions could be driving the association with mortality (1–4, 17, 32). Our results, which show the same to be true in a white-collar cohort of men across a wide age range (from 35 to 55 years at study entry), add to the evidence that

Table 2. Association Between Occupational Position at Baseline and Social Support at Baseline and at Last Follow-up in Study Participants, Whitehall II Study, 1985–2009

	Men (n = 6,339)		Women (n = 2,994)		P Value[a]
	OR[b]	95% CI	OR[b]	95% CI	
Baseline					
Low level of confiding/ emotional support	1.48	1.20, 1.82	0.74	0.55, 0.99	<0.001
Low level of practical support	1.79	1.46, 2.20	0.77	0.60, 0.99	<0.001
High level of negative aspects of close relationships	1.52	1.25, 1.84	1.11	0.86, 1.44	0.040
Low network score	1.30	1.06, 1.59	1.68	1.25, 2.24	0.140
Not married/cohabiting	5.19	4.17, 6.45	0.70	0.54, 0.90	<0.001
Last follow-up[c]					
Low level of confiding/ emotional support	1.96	1.53, 2.50	0.85	0.64, 1.14	<0.001
Low level of practical support	1.90	1.48, 2.44	0.97	0.74, 1.28	<0.001
High level of negative aspects of close relationships	1.43	1.09, 1.89	1.02	0.74, 1.42	0.150
Low network score	1.74	1.35, 2.23	0.80	0.61, 1.06	<0.001
Not married/cohabiting	5.39	4.10, 7.09	0.87	0.66, 1.16	<0.001

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] P for interaction between sex and occupational position.

[b] Occupational position was entered as a 3-level categorical variable; the odds ratio of the lowest occupational position versus the highest is reported here.

[c] Phase 7, the last phase at which data on social support were collected.

social support may play an important role in men's health. Overall, marital status more strongly predicted mortality than did the other indicators of social support that we examined, as reported previously (2, 5, 6). The association between network score and all-cause mortality was no longer significant after adjustment for SES and self-rated health, suggesting that part of the effect of social networks on health is either mediated or confounded by these 2 factors. The association between network score and cardiovascular mortality was also attenuated after adjustment for SES and self-rated health, but a 66% increased risk of death for participants with a low network score remained.

Although much of the evidence linking social support to mortality is based on studies that used structural measures (8, 33), functional measures are often thought to be better indicators of social support under the hypothesis that the actual support provided by the social network rather than its mere existence matters for health (10). A recent meta-analysis (34) showed that functional measures of support were associated with a 46% increase in the odds of survival. Our findings are in contrast with this result, as even in men we did not observe an association between perceived confiding/emotional support or practical support and mortality. In women, an inverse association was found, such that low levels of confiding/emotional support and practical support were associated with a lower mortality risk. However, low perceived emotional support and high negative aspects of close relationships have been related to increased psychiatric distress and heart disease in the present cohort (13, 35).

Reverse causation bias could in part explain the protective effect of low levels of perceived support on mortality, as comorbid conditions might be associated with both an increased level of support received and a higher mortality risk. In the present study, to account for reverse causation, all analyses were adjusted for self-rated health, a valid measure of health (36). In addition, analyses of the association between measures of social support and mortality were rerun excluding the deaths that occurred up to 1 year after the assessment of social support at each phase. These analyses yielded results largely similar to those presented here (results not shown).

Another possible explanation for the protective effect of low levels of perceived support on mortality is that residual confounding by SES may still persist even when all analyses are adjusted for occupational position. However, further adjustment for educational level and income did not substantially change our results (results not shown). Finally, it is possible that although perceived support is related to morbidity, the structural aspects of support are what influence mortality risk. Indeed, the correlation between structural and functional measures of social support was generally low.

Social support was not associated with cancer mortality in this study. Results from previous studies have been inconsistent (37–41). In a recent meta-analysis, Pinquart et al. (40) concluded that high levels of perceived social support, larger

Table 3. Associations Between Measures of Social Support[a] and All-Cause Mortality and Cardiovascular Mortality in the Whitehall II Study, 1985–2009

	All-Cause Mortality				CVD Mortality			
	Men (n = 6,339; deaths = 519)		Women (n = 2,994; deaths = 225)		Men (n = 6,334; deaths = 168)		Women (n = 2,990; deaths = 44)	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Confiding/emotional support								
Quartiles 2, 3, and 4	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Quartile 1[b]								
Adjusted for age	0.97	0.80, 1.17	0.68	0.50, 0.93	1.18	0.85, 1.63	0.76	0.38, 1.52
Additionally adjusted for SES and SRH	0.89	0.74, 1.08	0.68	0.49, 0.93	1.07	0.77, 1.48	0.79	0.40, 1.56
Practical support								
Quartiles 2, 3, and 4	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Quartile 1[b]								
Adjusted for age	1.05	0.87, 1.27	0.73	0.55, 0.96	1.36	1.00, 1.87	0.88	0.48, 1.63
Additionally adjusted for SES and SRH	1.01	0.84, 1.22	0.76	0.58, 1.01	1.27	0.92, 1.74	1.02	0.55, 1.88
Negative aspects of close relationships								
Quartiles 1, 2, and 3	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Quartile 4[b]								
Adjusted for age	0.85	0.69, 1.05	0.94	0.69, 1.27	1.05	0.74, 1.49	0.74	0.35, 1.54
Additionally adjusted for SES and SRH	0.76	0.62, 0.95	0.84	0.62, 1.14	0.91	0.64, 1.30	0.61	0.29, 1.27
Network score								
Quartiles 2, 3, and 4	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Quartile 1[b]								
Adjusted for age	1.27	1.07, 1.52	1.20	0.92, 1.57	1.85	1.36, 2.51	1.40	0.77, 1.55
Additionally adjusted for SES and SRH	1.18	0.99, 1.40	1.18	0.90, 1.53	1.66	1.22, 2.26	1.40	0.77, 1.54
Marital status								
Married or cohabiting	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Not married/cohabiting								
Adjusted for age	1.77	1.45, 2.16	1.14	0.87, 1.48	2.69	1.95, 3.71	1.52	0.84, 2.76
Additionally adjusted for SES and SRH	1.51	1.23, 1.86	1.14	0.88, 1.49	2.16	1.55, 3.03	1.66	0.92, 3.01

Abbreviations: CI, confidence interval; HR, hazard ratio; SES, socioeconomic status; SRH, self-rated health.

[a] Measures were entered into the models as time-dependent variables. None of the measures of social support was related to cancer mortality (results not shown).

[b] Results are for the lowest quartile (or highest quartile for negative aspects of close relationships) compared with the other 3 quartiles grouped together, which served as the reference categories (see Materials and Methods).

social networks, and being married were associated with decreased cancer mortality among cancer patients. However, the evidence linking social support to cancer mortality has been less consistent among nonpatient populations, such as that in the Whitehall II Study (41, 42). It is thus possible that social support plays a role only in patient survival after cancer diagnosis, an effect that cannot be detected in our study.

Sex differences in social support

In the present study, the social patterning of social support differed by sex, in that men of higher SES reported higher levels of perceived support, had higher network scores, and were more frequently married, whereas women of higher SES had lower levels of support and were more frequently unmarried. In this cohort, this pattern might be related to the ''marriage bar'' rule, which until the late 1960s/early 1970s forced female civil servants to resign if they got married (43). This meant that married women were unlikely to be in the civil service long enough to be promoted into the higher grades, as also shown by the different distribution of men and women across the socioeconomic categories in this cohort (Table 1). Results for women in the Whitehall II Study thus might not be generalizable to other occupational

Table 4. Impact of Measures of Social Support on the Association Between Occupational Position and Mortality in Men in the Whitehall II Study, 1985–2009

	All-Cause Mortality (n = 6,339, deaths = 519)				CVD Mortality (n = 6,334, deaths = 168)			
	HR[a]	95% CI	% Change[b]	95% CI[c]	HR[a]	95% CI	% Change[b]	95% CI
Model 1 (adjusted for age)	1.96	1.50, 5.56			3.12	1.98, 4.92		
Model 2 (adjusted for age and SRH)	1.59	1.21, 2.08			2.48	1.56, 3.92		
Model 2 additionally adjusted for network score	1.56	1.19, 2.04	−4	−12, −2	2.33	1.47, 3.69	−7	−15, −3
Model 2 additionally adjusted for marital status	1.43	1.08, 1.87	−23	−35, −10	1.98	1.24, 3.16	−23	−42, −12
Model 2 additionally adjusted for both network score and marital status	1.40	1.07, 1.85	−27	−43, −14	1.86	1.16, 2.98	−29	−52, −17

Abbreviations: CI, confidence interval; HR, hazard ratio; SRH, self-rated health.

[a] The hazard ratios are for the lowest occupational position versus the highest, obtained by squaring the coefficient for socioeconomic status in the regression models (see Materials and Methods).

[b] Percentage of attenuation in log HR = $100 \times (\beta_{\text{Model 2}} - \beta_{\text{Model 2 + social support(s)}})/(\beta_{\text{Model 2}})$, where $\beta = \log(\text{HR})$.

[c] Bias-corrected accelerated bootstrap 95% confidence interval.

cohorts that were more recently established or to the general population of working women.

Structural measures of social support, SES, and mortality

Social support and social connectedness have been suggested as possible fundamental social causes of social inequalities in health (44). However, very few studies have examined the mediating role of social support in the association between SES and health, and studies that have done so have produced inconsistent results (25, 45–49). Some studies found no evidence that social support, measured through structural measures, functional measures, or both, contributed to the association between SES and mortality after acute myocardial infarction (47), SES and self-rated health and hypertension (25), or SES and stroke risk (46). Instead, Avendano et al. (49) and Liu et al. (48) both used structural measures of social support and found them to contribute to approximately one-third of the socioeconomic gradients in stroke risk and mortality, respectively. In the present study, the structural measures of support (social network size and marital status) explained 27% and 29% of the socioeconomic gradients in all-cause and cardiovascular mortality, respectively, in men. The greater attenuation occurred after adjustment for marital status.

Strengths and weaknesses

The present study has 3 major strengths. First, unlike most previous studies, we used both structural and functional measures of social support in the same study. Second, we used repeated measurements of social support over the follow-up period to account for changes that may have occurred during the study period. Third, we provided a confidence interval for the contribution of social support to the association between SES and mortality, allowing us to add a degree of precision around the estimate of the attenuations.

This study also has several limitations. First, functional measures of social support were self-reported, and thus they may be dependent on the personality characteristics of the respondents (30). Moreover, they were based on the support received from the closest person only; other sources of support were not examined. However, these measures were derived from a well-validated questionnaire (30) and have been associated with other health outcomes in previous studies (13, 18). In addition, we focused on domestic social support and did not examine social support at work, which is also likely to contribute to socioeconomic differences in health (50). Second, a comprehensive measurement of social support was not available at study baseline (phase 1).

Another limitation relates to the fact that the association between SES and mortality in women was not statistically significant at conventional levels whether SES was assessed as a continuous or a categorical variable, and the contribution of social support to socioeconomic differences in mortality could be examined in men only. Previous studies have reported less social inequality in mortality risk in women than in men when women's own occupation was used as an indicator of SES instead of partner's occupation or indicators of social advantage of the household (51–53). It is thus possible that the measure of SES used in this study, civil service employment grade, does not correctly classify women's SES. It is also possible that SES differences in mortality are not detected in women because almost half of the sample is in the lowest SES category, leaving a relatively small number of women (and deaths) in the higher SES groups. Finally, it is important to consider that the Whitehall II Study cohort is a cohort of white-collar civil servants with stable jobs; the findings might not be generalizable to the general population.

Conclusions

These data suggest that in men, not being married or cohabitating is an important risk factor for mortality. It also

contributes to the association between socioeconomic status and mortality.

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