

# Personality, lifestyle, and risk of cardiovascular disease and cancer: follow-up of population based cohort

Til Stürmer, Petra Hasselbach, Manfred Amelang

## Abstract

**Objective** To study the relation between measures of personality and risk of cardiovascular disease and cancer in a large cohort.

**Design** Follow-up of population based cohort.

**Setting** Heidelberg, Germany.

**Participants** 5114 women and men aged 40-65 in 1992-5.

**Main outcome measures** Psychological traits assessed by several standardised personality questionnaires in 1992-5, related to cause of death (to 2002-3) or reported incidence of cardiovascular diseases and cancer (validated by treating doctors). Relative risks (and 95% confidence intervals) for combined morbidity and mortality according to five important personality traits were estimated using multivariable Cox proportional hazards models.

**Results** During median follow-up of 8.5 years, 257 participants died and 72 participants were diagnosed with a heart attack, 62 with stroke, and 240 with cancer (morbidity and mortality combined). A high internal locus of control over disease was associated with a decreased risk of myocardial infarction (adjusted relative risk for an increase of 1 SD = 0.75; 95% confidence interval 0.58 to 0.96). An increase of 1 SD in time urgency was associated with a decreased risk of cancer (adjusted relative risk 0.83; 0.73 to 0.95). Other major personality traits—anger control, psychoticism, and symptoms of depression—were not consistently associated with myocardial infarction, stroke, or cancer.

**Conclusion** Internal locus of control over disease and time urgency seem to be associated with reduced risk for common chronic diseases, probably by affecting unmeasured health related behaviour. The other personality traits assessed had no major impact on cardiovascular disease and cancer.

## Introduction

A recent large multinational case-control study linked permanent stress during the past year to increased incidence of myocardial infarction.<sup>1</sup> The size of the effect of psychosocial factors was similar to that seen for abdominal obesity, diabetes, and hypertension.<sup>2</sup> The proposed pathophysiological links between psychological stress and cardiovascular disease include clustering of “traditional” risk factors, endothelial dysfunction, myocardial ischaemia, plaque rupture, thrombosis, and malignant arrhythmias.<sup>3,4</sup>

Evidence for a link between psychological factors and cancer is weak.<sup>5</sup> A meta-analysis of stressful life events and risk of breast cancer did not support an overall association between such events and breast cancer.<sup>6</sup> We hypothesised that personality differences influence the incidence of and mortality from cardiovascular disease and cancer, independent of “traditional” risk factors. We empirically derived five personality scales that measure independent personality traits<sup>7</sup> and present results on all five scales.

## Methods

We identified a representative sample of women and men aged 40-65 from the population registry of Heidelberg, Germany. Between 1992 and 1995, 5114 of these people completed a baseline questionnaire on psychological traits, lifestyle factors, and comorbidity. In 2002, we mailed a follow-up questionnaire to all participants and asked for information about chronic diseases diagnosed since baseline.

### Personality variables

We used both broad measures of personality (extraversion, neuroticism, psychoticism) and specific scales (depression, time urgency, hostility, anger out, low sense of coherence, irritability, optimism, anger in, anger control, social support, exaggerated social control, internal and external locus of control over disease, jealousy). We aggregated the data from all measures to obtain five broad independent dimensions of personality.<sup>7</sup>

### Morbidity and mortality

We validated all diagnoses of myocardial infarction, stroke, and cancer since baseline by contacting the treating doctors. Mortality follow-up was 99.6%. We assessed the cause of death from death certificates for 98.8% of participants who had died.

### Covariates

We assessed the risk factors for chronic diseases that might be associated with personality variables at baseline. Besides age and sex, these were body mass index; smoking status; alcohol consumption; exercise; comorbidity (history of myocardial infarction, stroke, cancer, hypertension, hyperlipidaemia, and diabetes); family history of myocardial infarction, stroke, and cancer; and education.

### Statistical analyses

We used Cox proportional hazards models to assess the association between each personality scale and the incidence of myocardial infarction, stroke, or cancer. See [bmj.com](http://bmj.com) for details.

## Results

From the original cohort 4267 (83.4%) participants replied to the follow-up questionnaire or died during follow-up. Mean age was 53.4 years; 51.5% were women.

During a median follow-up of 8.5 years, 257 participants died, 72 participants had a heart attack, 62 participants had a stroke, and 240 participants were diagnosed with cancer (morbidity and mortality combined).

Divisions of Pharmacoeconomics and Preventive Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA 02120, USA

Til Stürmer  
visiting associate  
professor of medicine

Department of Psychology, University of Heidelberg, Germany

Petra Hasselbach  
research fellow  
Manfred Amelang  
professor of psychology

Correspondence to:  
T Stürmer  
til.sturmer@post.harvard.edu

BMJ 2006;332:1359-62



An additional table is on [bmj.com](http://bmj.com)



This is the abridged version of an article that was posted on [bmj.com](http://bmj.com) on 10 May 2006: <http://bmj.com/cgi/doi/10.1136/bmj.38833.479560.80>

**Table 1** Personality variables and incident myocardial infarction (morbidity and mortality) in the Heidelberg cohort (4267 participants)\*

Personality scale	Person years (n=32 875)	No of events (n=72)	Incidence/100 000 person years (219 overall)	Relative risk (95% CI)†		
				Unadjusted	Adjusted for age and sex	Fully adjusted‡
<b>Symptoms of depression</b>						
Low	10 288	21	204	0.81 (0.46 to 1.42)	0.80 (0.45 to 1.41)	0.89 (0.48 to 1.64)
Medium	11 146	28	251	1.00	1.00	1.00
High	11 366	23	202	0.80 (0.46 to 1.39)	0.87 (0.50 to 1.51)	0.80 (0.44 to 1.43)
1 SD increase	—	—	—	1.08 (0.86 to 1.35)	1.17 (0.93 to 1.49)	1.09 (0.84 to 1.40)
<b>Anger control</b>						
Low	9 504	16	168	0.71 (0.39 to 1.31)	0.88 (0.48 to 1.63)	0.99 (0.53 to 1.86)
Medium	12 198	29	238	1.00	1.00	1.00
High	11 103	27	243	1.02 (0.60 to 1.72)	0.81 (0.48 to 1.37)	0.80 (0.45 to 1.40)
1 SD increase	—	—	—	1.17 (0.92 to 1.48)	0.97 (0.77 to 1.23)	0.91 (0.71 to 1.17)
<b>Time urgency</b>						
Low	11 570	26	228	1.30 (0.72 to 2.38)	1.43 (0.79 to 2.62)	1.85 (0.94 to 3.62)
Medium	10 424	18	173	1.00	1.00	1.00
High	10 881	28	257	1.49 (0.82 to 2.69)	1.30 (0.72 to 2.36)	1.68 (0.86 to 3.25)
1 SD increase	—	—	—	1.09 (0.87 to 1.38)	0.99 (0.78 to 1.26)	0.99 (0.77 to 1.26)
<b>Internal locus of control over disease</b>						
Low	10 218	30	294	1.47 (0.85 to 2.55)	1.65 (0.95 to 2.86)	1.84 (1.01 to 3.32)
Medium	11 007	22	200	1.00	1.00	1.00
High	11 650	20	172	0.86 (0.47 to 1.57)	0.81 (0.44 to 1.48)	0.77 (0.41 to 1.46)
1 SD increase	—	—	—	0.87 (0.69 to 1.09)	0.80 (0.63 to 1.01)	0.75 (0.58 to 0.96)
<b>Psychoticism</b>						
Low	6 980	18	258	1.45 (0.81 to 2.59)	1.55 (0.87 to 2.79)	1.59 (0.88 to 2.87)
Medium	17 414	31	178	1.00	1.00	1.00
High	8 411	23	273	1.53 (0.89 to 2.63)	1.48 (0.86 to 2.54)	1.28 (0.71 to 2.30)
1 SD increase	—	—	—	1.22 (1.06 to 1.41)	1.23 (1.05 to 1.44)	1.21 (1.01 to 1.45)

\*128 participants had myocardial infarction at baseline; 247 participants lacked information on incident myocardial infarction during follow-up; 72 incident cases of myocardial infarction (including 31 deaths) occurred.

†Incidence rate ratios and their 95% confidence intervals from Cox proportional hazards model controlling for all variables in table 1: age (continuous), sex, body mass index (3 categories), smoking (never, former, current), alcohol consumption (4 categories), exercise (4 categories), comorbidity (history of stroke, cancer, hypertension, hyperlipidaemia, and diabetes), family history of myocardial infarction, and education (4 categories). Fully adjusted models based on 3700 participants for anger control, 3705 for time urgency, 3705 for internal locus of control over disease, 3698 for psychoticism, and 3697 for symptoms of depression, and 66 events owing to missing information on covariates.

Tables 1-3 show the five personality scales at baseline as predictors of incident myocardial infarction, stroke, and cancer during follow-up. We compared the low and the high categories with the medium categories and show the relative risk associated with an increase of 1 SD (standard deviation) in the personality scales.

Anger control, time urgency, and symptoms of depression were not associated with the incidence of myocardial infarction (table 1). Participants with a low internal locus of control over disease had an adjusted relative risk of 1.84 (95% confidence interval 1.01 to 3.32) compared with those with a medium internal locus of control, and participants with a high internal locus of control over disease had a relative risk of 0.77 (0.41 to 1.46). An increase of 1 SD in internal locus of control over disease was associated with a relative risk of 0.75 (0.58 to 0.96). The relative risks of myocardial infarction were 1.59 (0.88 to 2.87) and 1.28 (0.71 to 2.30) for participants with low and high psychoticism compared with those with a medium degree of psychoticism. An increase of 1 SD was associated with a relative risk of 1.21 (1.01 to 1.45).

None of the personality scales was strongly associated with the incidence of stroke (table 2). Higher values of symptoms of depression, anger control, and time urgency showed a monotonic association with increased risk of incident stroke. In the fully adjusted models, these trends were less pronounced. Higher degrees of psychoticism were associated with a decreased risk of stroke, and this trend was more pronounced after we controlled for confounding.

Table 3 shows that anger control, internal locus of control over disease, psychoticism, and symptoms of depression were not associated with cancer. Time urgency was inversely associated with the risk of cancer; participants with high time urgency had a relative risk for cancer of 0.68 (0.49 to 0.95) compared with those with medium time urgency, and an increase in time urgency of 1 SD was associated with an adjusted relative risk for cancer of 0.83 (0.73 to 0.95).

## Discussion

In a large, population based cohort study with a median follow-up of 8.5 years some personality traits were risk factors for morbidity and mortality, independent of lifestyle factors. A low internal locus of control over disease and high and low psychoticism were risk factors for myocardial infarction. A high time urgency was associated with reduced risk of developing cancer. Overall, however, the personality traits had no major impact on the incidence of and mortality from cardiovascular disease and cancer.

### Comparison with other studies

Studies assessing the association between type A behaviour (the triad of competitive ambition, time urgency, and hostility) and cardiovascular disease have had mixed results.<sup>8-11</sup> Because type A behaviour has now been deconstructed, we analysed anger control (inversely associated with hostility) and time urgency separately.<sup>12</sup> Neither personality trait was associated

with cardiovascular disease. Our results on myocardial infarction agree with those on control over life circumstances seen in a large case-control study.<sup>1</sup> Residual confounding by healthy behaviours apart from those that we could control for is a likely explanation for at least part of the reduced risk.

Our finding of increased risk for myocardial infarction with increasing psychoticism needs to be interpreted with caution because of the inconsistency of the results. High values of psychoticism have been associated with less health conscious behaviour in at least one study, but not with myocardial infarction.<sup>13</sup>

Our finding of no association between personality traits and stroke is interesting in the light of emerging research on the individual components of composite end points and the greater contribution of stroke than myocardial infarction to overall risk of cardiovascular disease in women.<sup>14</sup>

A recent review of the association between psychological factors and cancer concluded that life events (other than loss of a spouse or child), negative emotional states, fighting spirit, stoic acceptance or fatalism, active coping, personality factors, and locus of control have little influence on whether people develop cancer or not.<sup>5</sup> We found that a high time urgency was associated with a lower risk of cancer, but the strength of the association was moderate, and risk was not increased in the category of low time urgency. High time urgency might be associated with delayed diagnosis and thus lower incidence of cancer. By looking at cancer overall, we may have missed associations with individual types of cancer.<sup>6, 15</sup>

### What is already known on this topic

Evidence of an effect of personality on disease is best for stress and cardiovascular disease, but little evidence exists for cancer

### What this study adds

Overall, the personality traits assessed had no major impact on incidence of and mortality from cardiovascular disease and cancer

Higher internal locus of control over disease (a patient's belief that the onset and progress of disease is a result of their behaviour) may be associated with a reduced risk of myocardial infarction but not of stroke or cancer

Higher time urgency may be associated with a reduced risk of cancer but not of cardiovascular disease (myocardial infarction and stroke)

### Limitations

We lack information on important risk factors for cardiovascular disease and cancer, including blood lipids, markers of subclinical systemic inflammation, diet, and use of drugs (for example, low dose aspirin, statins) during follow-up. Personality variables could be associated with long term use of preventive drugs, screening practices, and reporting of symptoms.<sup>16</sup> Despite the population based recruitment, participants probably do not represent the whole range of personalities in the population. We might have missed associations between extreme patterns of these traits and disease.

**Table 2** Personality variables and incident stroke (morbidity and mortality) in the Heidelberg cohort (4267 participants)\*

Personality scale	Person years (n=33 247)	No of events (n=62)	Incidence/100 000 person years (186 overall)	Relative risk (95% CI)†		
				Unadjusted	Adjusted for age and sex	Fully adjusted‡
<b>Symptoms of depression</b>						
Low	10 329	12	116	0.73 (0.35 to 1.51)	0.79 (0.38 to 1.65)	0.91 (0.43 to 1.94)
Medium	11 322	18	159	1.00	1.00	1.00
High	11 522	32	278	1.74 (0.98 to 3.10)	1.68 (0.94 to 3.02)	1.53 (0.83 to 2.80)
1 SD increase	—	—	—	1.26 (1.02 to 1.55)	1.26 (1.01 to 1.58)	1.13 (0.88 to 1.46)
<b>Anger control</b>						
Low	9 665	14	145	0.78 (0.40 to 1.52)	0.91 (0.47 to 1.76)	0.87 (0.44 to 1.75)
Medium	12 298	23	187	1.00	1.00	1.00
High	11 213	25	223	1.19 (0.68 to 2.10)	1.04 (0.59 to 1.84)	1.15 (0.64 to 2.07)
1 SD increase	—	—	—	1.14 (0.88 to 1.46)	1.01 (0.78 to 1.30)	1.04 (0.80 to 1.36)
<b>Time urgency</b>						
Low	11 718	16	137	0.84 (0.42 to 1.66)	0.84 (0.42 to 1.67)	0.76 (0.38 to 1.54)
Medium	10 404	17	163	1.00	1.00	1.00
High	11 125	29	261	1.60 (0.88 to 2.91)	1.45 (0.80 to 2.65)	1.28 (0.69 to 2.36)
1 SD increase	—	—	—	1.24 (0.97 to 1.59)	1.19 (0.93 to 1.53)	1.15 (0.89 to 1.48)
<b>Internal locus of control over disease</b>						
Low	10 328	17	165	0.77 (0.41 to 1.43)	0.79 (0.42 to 1.47)	0.79 (0.42 to 1.49)
Medium	11 126	24	216	1.00	1.00	1.00
High	11 794	21	178	0.82 (0.46 to 1.48)	0.79 (0.44 to 1.42)	0.65 (0.35 to 1.21)
1 SD increase	—	—	—	1.14 (0.89 to 1.47)	1.11 (0.86 to 1.43)	1.01 (0.78 to 1.30)
<b>Psychoticism</b>						
Low	7 111	14	197	1.01 (0.54 to 1.89)	1.18 (0.63 to 2.21)	1.20 (0.64 to 2.27)
Medium	17 543	34	194	1.00	1.00	1.00
High	8 525	14	164	0.85 (0.46 to 1.58)	0.83 (0.45 to 1.55)	0.70 (0.36 to 1.36)
1 SD increase	—	—	—	0.94 (0.72 to 1.25)	0.89 (0.67 to 1.20)	0.81 (0.58 to 1.12)

\*64 participants had stroke at baseline; 274 participants lacked information on incident stroke during follow-up; 62 incident cases of stroke (no deaths) occurred.

†Incidence rate ratios and their 95% confidence intervals from Cox proportional hazards model controlling for all variables in table 1: age (continuous), sex, body mass index (3 categories), smoking status (never, former, current), alcohol consumption (4 categories), exercise (4 categories), comorbidity (history of stroke, cancer, hypertension, hyperlipidaemia, and diabetes), family history of stroke, and education (4 categories). Fully adjusted models based on 3741 participants for anger control, 3746 for time urgency, 3746 for internal locus of control over disease, 3739 for psychoticism, and 3738 for symptoms of depression, and 59 events owing to missing information on covariates.

**Table 3** Personality variables and incident cancer (morbidity and mortality) in the Heidelberg cohort (4267 participants)\*

Personality scale	Person years (n=31 257)	No of events (n=240)	Incidence/100 000 person years (768 overall)	Relative risk (95% CI)†		
				Unadjusted	Adjusted for age and sex	Fully adjusted‡
<b>Symptoms of depression</b>						
Low	9 878	79	800	1.26 (0.91 to 1.75)	1.37 (0.99 to 1.91)	1.35 (0.96 to 1.88)
Medium	10 493	66	629	1.00	1.00	1.00
High	10 810	95	879	1.39 (1.02 to 1.91)	1.31 (0.95 to 1.79)	1.18 (0.85 to 1.63)
1 SD increase	—	—	—	1.09 (0.97 to 1.23)	1.06 (0.93 to 1.20)	1.00 (0.87 to 1.15)
<b>Anger control</b>						
Low	9 106	56	615	0.80 (0.57 to 1.12)	0.86 (0.62 to 1.20)	0.87 (0.62 to 1.23)
Medium	11 615	90	775	1.00	1.00	1.00
High	10 479	93	887	1.14 (0.85 to 1.53)	1.09 (0.81 to 1.46)	1.14 (0.84 to 1.54)
1 SD increase	—	—	—	1.10 (0.97 to 1.25)	1.04 (0.91 to 1.19)	1.06 (0.93 to 1.22)
<b>Time urgency</b>						
Low	10 856	93	857	1.04 (0.77 to 1.40)	1.06 (0.78 to 1.42)	1.08 (0.80 to 1.47)
Medium	9 746	81	831	1.00	1.00	1.00
High	10 654	66	619	0.74 (0.54 to 1.03)	0.71 (0.51 to 0.98)	0.68 (0.49 to 0.95)
1 SD increase	—	—	—	0.87 (0.76 to 0.99)	0.85 (0.74 to 0.96)	0.83 (0.73 to 0.95)
<b>Internal locus of control over disease</b>						
Low	9 716	85	875	1.25 (0.92 to 1.71)	1.25 (0.92 to 1.72)	1.20 (0.87 to 1.66)
Medium	10 391	73	703	1.00	1.00	1.00
High	11 149	82	735	1.04 (0.76 to 1.43)	1.01 (0.74 to 1.38)	1.00 (0.72 to 1.38)
1 SD increase	—	—	—	0.99 (0.87 to 1.13)	0.98 (0.86 to 1.11)	0.98 (0.86 to 1.12)
<b>Psychoticism</b>						
Low	6 577	55	836	1.17 (0.85 to 1.62)	1.29 (0.93 to 1.77)	1.34 (0.97 to 1.85)
Medium	16 614	118	710	1.00	1.00	1.00
High	7 996	67	838	1.18 (0.87 to 1.59)	1.16 (0.86 to 1.57)	1.16 (0.85 to 1.58)
1 SD increase	—	—	—	1.06 (0.95 to 1.19)	1.04 (0.92 to 1.16)	1.01 (0.89 to 1.14)

\*242 participants had cancer at baseline; 256 participants lacked information on incident cancer during follow-up; 240 incident cases of myocardial infarction (including 83 deaths) occurred.

†Incidence rate ratios and their 95% confidence intervals from Cox proportional hazards model controlling for all variables in table 1: age (continuous), sex, body mass index (3 categories), smoking status (never, former, current), alcohol consumption (4 categories), exercise (4 categories), comorbidity (history of stroke, cancer, hypertension, hyperlipidaemia, and diabetes), family history of cancer, and education (4 categories). Fully adjusted models based on 3587 participants for anger control, 3591 for time urgency, 3591 for internal locus of control over disease, 3584 for psychoticism, and 3583 for symptoms of depression, and 230 events owing to missing information on covariates.

**Implications**

Psychological traits such as the personality variables considered in our analysis are probably stable over time and are likely to have a genetic component.<sup>17 18</sup> The more these traits are predetermined, the more they should be seen as part of a risk prediction rather than be used for “victim blaming”.

Since the personality variables and lifestyle factors were assessed at the same time, we cannot tell how personality variables influenced lifestyle factors. Psychological traits probably influence the risk of disease only after long latency periods, but they might have more immediate effects through variables such as lifestyle factors (smoking, alcohol consumption, and weight).<sup>19</sup> Repeated measures and more sophisticated models are needed to determine the causal effect of personality differences on the risk of disease.

Contributors: See bmj.com.

Funding: German Research Foundation (research grant AM 37/19-1).

Competing interests: None declared.

Ethical approval: Ethics committee-I of the medical faculty of Heidelberg, Ruprecht-Karls University of Heidelberg, Germany.

- 1 Rosengren A, Hawken S, Ounpuu S, Sliwa K, Zubaid M, Almahmeed WA, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:953-62.
- 2 Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:937-52.
- 3 Merz CNB, Dwyer J, Nordstrom CK, Walton KG, Salerno JW, Schneider RH. Psychological stress and cardiovascular disease: pathophysiological links. *Behav Med* 2002;27:141-7.

- 4 Black PH, Garbutt LD. Stress, inflammation and cardiovascular disease. *J Psychosom Res* 2002;52:1-12.
- 5 Garssen B. Psychological factors and cancer development: evidence after 30 years of research. *Clin Psychol Rev* 2004;24:315-38.
- 6 Duijts SF, Zeegers MP, Borne BV. The association between stressful life events and breast cancer risk: a meta-analysis. *Int J Cancer* 2003;107:1023-9.
- 7 Amelang M, Hasselbach P, Stürmer T. Personality, cardiovascular disease, and cancer. *Z Gesundheitspsychol* 2004;12:102-15.
- 8 Ragland DR, Brand RJ. Type A behaviour and mortality from coronary heart disease. *N Engl J Med* 1988;318:65-9.
- 9 Haynes SG, Feinleib M, Kannel WB. The relationship of psychosocial factors to coronary heart disease in the Framingham study. III. Eight-year incidence of coronary heart disease. *Am J Epidemiol* 1980;111:37-58.
- 10 Shekelle RB, Hulley SB, Neaton JD, Billings JH, Borhani NO, Gerace TA, et al. The MRFIT behaviour pattern study. II. Type A behaviour and incidence of coronary heart disease. *Am J Epidemiol* 1985;122:559-70.
- 11 Carmelli D, Swan GE. The relationship of type A behaviour and its components to all-cause mortality in an elderly subgroup of men from the western collaborative group study. *J Psychosom Res* 1996;40:475-83.
- 12 Sutton S, Baum A, Johnston M, eds. *The Sage handbook of health psychology*. London: Sage, 2004.
- 13 Brayne C, Do KA, Green L, Green AC. Is health protective behaviour in adolescents related to personality? A study of sun protective behaviour and the Eysenck personality questionnaire (junior version) in Queensland. *Pers Individ Dif* 1998;25:889-95.
- 14 Glynn RJ, Rosner B. Methods to evaluate risks for composite end points and their individual components. *J Clin Epidemiol* 2004;57:113-22.
- 15 Butow PN, Hiller JE, Price MA, Thackway SV, Krickler A, Tennant CC. Epidemiological evidence for a relationship between life events, coping style, and personality factors in the development of breast cancer. *J Psychosom Res* 2000;49:169-81.
- 16 Macleod J, Smith GD, Heslop P, Metcalfe C, Carroll D, Hart C. Psychological stress and cardiovascular disease: empirical demonstration of bias in a prospective observational study of Scottish men. *BMJ* 2002;324:1247-51.
- 17 Vaidya JG, Gray EK, Haig J, Watson D. On the temporal stability of personality: evidence for differential stability and the role of life experiences. *J Pers Soc Psychol* 2002;83:1469-84.
- 18 Borkenau P, Riemann R, Angleitner A, Spinath FM. Genetic and environmental influences on observed personality: evidence from the German observational study of adult twins. *J Pers Soc Psychol* 2001;80:655-68.
- 19 Weitekamp R, Wildner M. Exploratory causal modeling in epidemiology: are all factors created equal? *J Clin Epidemiol* 2002;55:436-44.

(Accepted 13 April 2006)

doi 10.1136/bmj.38833.479560.80