Title: Perceived extrinsic mortality risk and health behaviour: Testing a behavioural ecological model

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Lay summary: If poorer people perceive that they are exposed to risks of death beyond their control, it may explain their tendency to invest less effort in looking after their health. This was the prediction of a theoretical evolutionary model, which we previously presented. The data in this paper provide evidence in support of our model.

Key words: Extrinsic mortality, health behaviour, behavioural ecology, model, socioeconomic, perceptions,

ABSTRACT:

Purpose:

Socioeconomic gradients in health behaviour are pervasive and well documented. Yet, outside the evolutionary literature, there is no consensus on their causes. Our previously presented theoretical behavioural ecological model predicted that people of low socioeconomic position (SEP) should perceive greater personal extrinsic mortality risk than those of higher SEP, leading them to disinvest in their future health. We collected data to test this prediction.

Methods:

We surveyed North American adults for measures of SEP, effort in looking after health and perceived extrinsic and intrinsic mortality risks. We examined the relationships between SEP, perceived mortality risks and effort in looking after health. We then tested whether the association between SEP and effort in looking after health was mediated by perceived extrinsic mortality risk.

Results:

SEP was associated with effort in looking after health. Lower SEP was also associated with higher perceived extrinsic mortality risk, which in turn predicted effort in looking after health. The effect of SEP on effort in looking after health was completely mediated by perceived extrinsic mortality risk.

Conclusions:

Our findings support the predictions of our previously presented theoretical model. They show that SEP gradients in perceptions of extrinsic mortality risk mirror known SEP gradients in actual extrinsic mortality risk. The large effect size for the relationship between perceived extrinsic mortality risk and health effort in our sample indicates that perceived extrinsic mortality risk may be a key predictor of health behaviour.

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Purpose

Socioeconomic gradients in health outcomes are pervasive and well documented (Adler & Ostrove, 1999; Melchior, Choquet, Le Strat, Hassler, & Gorwood, 2011); people of lower socioeconomic position have shorter life expectancies and shorter healthy life expectancies than those of higher SEP (Crimmins & Saito, 2001; Liao, McGee, Kaufman, Cao, & Cooper, 1999; Phelan, Link, & Tehranifar, 2010; Wilkinson, 1992). Evidence suggests that socioeconomic differences in health behaviour account for up to half of the socioeconomic health gradient (Mokdad, Marks, Stroup, & Gerberding, 2004; Stringhini et al., 2010). People of lower SEP are more likely to smoke or to drink excessively than those of higher SEP (Harrell, Bangdiwala, Deng, Webb, & Bradley, 1998; Pridemore, Tomkins, Eckhardt, Kiryanov, & Saburova, 2010), and are less likely to take part in regular physical activity (McLaren, 2007; Wardle, Waller, & Jarvis, 2002). They are also less likely to adhere to treatment programmes, even when there is no financial cost to doing so (Barr, Somers, Speizer, & Camargo, 2002; Goldman & Smith, 2002). The reasons for this SEP gradient in health behaviours have become an enduring point of debate across a range of disciplines including epidemiology, public health, health psychology, sociology and behavioural economics (Pampel, Krueger, & Denney, 2010).

Some socioeconomic differences in health behaviour may be attributed to a lack of resources to "purchase" health (Darmon & Drewnowski, 2008). However, this argument does not apply to some of the most common health behaviours. Smoking, poor diet, physical inactivity and alcohol consumption are major behavioural causes of mortality. Indeed, they were reported to have been the leading causes of death in the United States in the year 2000 (Mokdad et al., 2004). For at least two out of these four behaviours (smoking and alcohol consumption), the unhealthy option is financially more costly than the healthy one. Thus, the people who can least afford to spend money are spending money on behaviours that damage their health.

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Some authors have argued that the socioeconomic gradient in health behaviour is the result of socioeconomic differences in specific health knowledge (Siahpush, McNeill, Hammond, & Fong, 2006). However, providing specific health information does not change behaviour equally among high and low SEP individuals. Health campaigns designed to improve behaviour by informing people of the risks related to smoking, drinking and poor diet have greater effects among higher SEP individuals (Buck & Frosini, 2012; White, Adams, & Heywood, 2009). This raises the possibility that there is greater incentive for higher SEP individuals to invest in protecting their health than there is for individuals of lower SEP.

Many explanations for socioeconomic gradients in health behaviour have been put forward, but there is currently no consensus across disciplines (Cutler & Lleras-Muney, 2010; Pampel et al., 2010; Pepper & Nettle, 2013). We have argued that most of the explanations in the non-evolutionary literature are proximate ones, underpinned by a single ultimate explanation (Pepper & Nettle, 2013). In previous work, we presented a theoretical model of this ultimate explanation, using an adaptive framework from behavioural ecology (Nettle, 2010). The model divides the risk of mortality into two components: an extrinsic component, which remains the same regardless of the behavioural decisions that the individual makes, and an intrinsic component, which reflects how much effort the individual invests in preventing the health risks that can be mitigated. The model also assumes that health-protecting investments are costly, in the sense that the time and energy devoted to them must be taken away from other activities that individuals value. (There is a trade-off between investing in health behaviour and investing in other adaptively-relevant activities.) Finally, the model assumes there are diminishing returns in terms of increased life expectancy from each unit of investment in health behaviour.

The model shows that as the *extrinsic* component of mortality risk increases, the optimal investment in protective health behaviour decreases. Under conditions of high extrinsic mortality, the value of health-protecting investments is reduced, since even if one makes them, one may well be killed by something extrinsic anyway. Thus, people facing higher extrinsic mortality risks should

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reduce their investment in preventative health behaviour and reallocate their investment toward other things. This will further increase their *overall* mortality risk, amplifying the initial difference in extrinsic mortality into a larger difference in total mortality. Because of this exacerbatory effect, a small difference in extrinsic could lead to a large disparity in total mortality.

In our previous work we suggested that a key explanation of the socioeconomic gradient in health behaviour may be that individuals of lower SEP are exposed to greater extrinsic risk of mortality than people of higher SEP (Nettle, 2010; Pepper & Nettle, 2013). They thus respond, as the model would predict, buy reducing investments in preventative health behaviour and channelling their energies in other directions. This is a contentious claim, as it implies that the lower investment in health of people in low-SEP communities is an adaptive response to their (perceived) environment rather than, for example, a mistake due to ignorance. Thus, it is important to test empirically the assumptions and predictions of our model.

It is important to note that our behavioural ecological model, though specific to health behaviours, parallels life history theory. Life history theory predicts that certain adaptively relevant behaviours such as reproductive scheduling and parental investment should be sensitive to mortality rates (Chisholm et al., 1993; Wilson & Daly, 1997). Indeed, empirical work has demonstrated associations between mortality rates and such indicators of life history strategy (Low, Hazel, Parker, & Welch, 2008; Nettle, Coall, & Dickins, 2011; Quinlan, 2010). However, little has been done specifically to investigate the associations between *extrinsic* mortality risk, and *health* behaviour, or to test how *perceptions* of mortality risk relate to health behaviour.

In this paper, we report our findings from a survey of North American adults, which included questions designed to test aspects of our model. We collected measures of SEP, current investment in health, and perceived risk of mortality. Perceived risk of mortality, or its inverse, subjective life expectancy, has been widely studied before (Dunkel, Mathes, & Decker, 2010; Krupp, 2012), but we introduced a novel method to discriminate the extrinsic component of

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perceived mortality from the intrinsic component. Based on our model, we made the following predictions:

1. Lower SEP will be associated with greater perceived extrinsic mortality in particular, rather than perceived intrinsic mortality.

2. Greater perceived extrinsic mortality will be associated with lower reported effort in looking after health.

3. The relationship between SEP and reported effort in looking after health will be mediated by perceived extrinsic mortality.

Methods

Data collection

The study was approved by the Newcastle University Faculty of Medical Sciences Ethics Committee. 600 North American volunteers were surveyed anonymously online using the SocialSci survey platform [www.socialsci.com]. Respondents had previously signed up to take part in surveys via this platform. SocialSci recruit using a distributed online advertising network, print media and live recruitment. They award Amazon (www.amazon.com) credit to respondents for taking part in their surveys. Respondents completed an electronic consent form before proceeding. They were then asked for basic demographic information. Following this, we collected measures of self-reported SEP, subjective risk of mortality, and effort spent in looking after health.

Measures of SEP

We measured SEP in two different ways. First, we asked respondents for their annual income in US$. Income was square-root transformed for analysis. In addition, respondents were asked to complete a subjective measure of current SEP taken from prior studies by Griskevicius et al. (Griskevicius, Tybur, Delton, & Robertson, 2011). They were asked to rate their agreement on a scale from one (strongly disagree) to seven (strongly agree) with the statements: a) “I don’t worry too much about paying my bills”; b) “I have enough money to buy things I want”, and; c) “I don’t think I’ll have to worry about money too much in the future.” The three responses correlated well with one another (r=0.56-0.68, p<0.01) and hence we summed them to give an overall subjective SEP score. The income and subjective SEP measures were correlated with one another (r=0.33, p<0.01), but not so highly as to treat them as equivalent. Income and SEP were therefore entered separately into all our analyses.

Effort in looking after health

As a measure of investment in health, respondents were asked to indicate their answer to the following on a scale, "How much effort do you make to look after your health and ensure your safety these days? 0 is 'no effort at all' and 100 is 'the maximum effort you could make'."

Perceived risk of extrinsic and intrinsic mortality

We created two novel survey items to separate out the extrinsic and intrinsic components of perceived mortality risk. We asked, "If you made the maximum effort you could make to look after your health and ensure your safety, what do you think the chances would be that you would live to be 75 or more? Again, 0 is 'no chance' and 100 is 'definitely." The extrinsic component of subjective mortality risk (henceforth *perceived extrinsic mortality risk*) is 100 minus this response. We then asked respondents, "If you made no effort at all to look after your health and ensure your safety, what do you think the chances would be that you would live to be 75 or more? Again, 0 is 'no chance' and 100 is 'definitely." Our *perceived intrinsic mortality risk* variable was the difference between the preceding question and this one. The relationship between our original measures and these variables is illustrated in

Fig 1. We have also illustrated the predicted relationship between perceived mortality risks and SEP in Figure 2a.

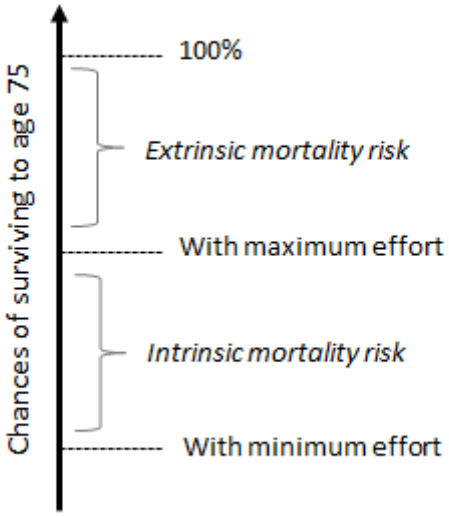

Fig 1. Schematic of our measures of perceived extrinsic and intrinsic mortality risk. The perceived extrinsic risk is the difference between 100% and the reported chances of surviving to age 75 with maximum effort in looking after health. The perceived intrinsic risk is the difference between the reported chances of living to 75 with maximum effort in looking after health, and with minimum effort in looking after health.

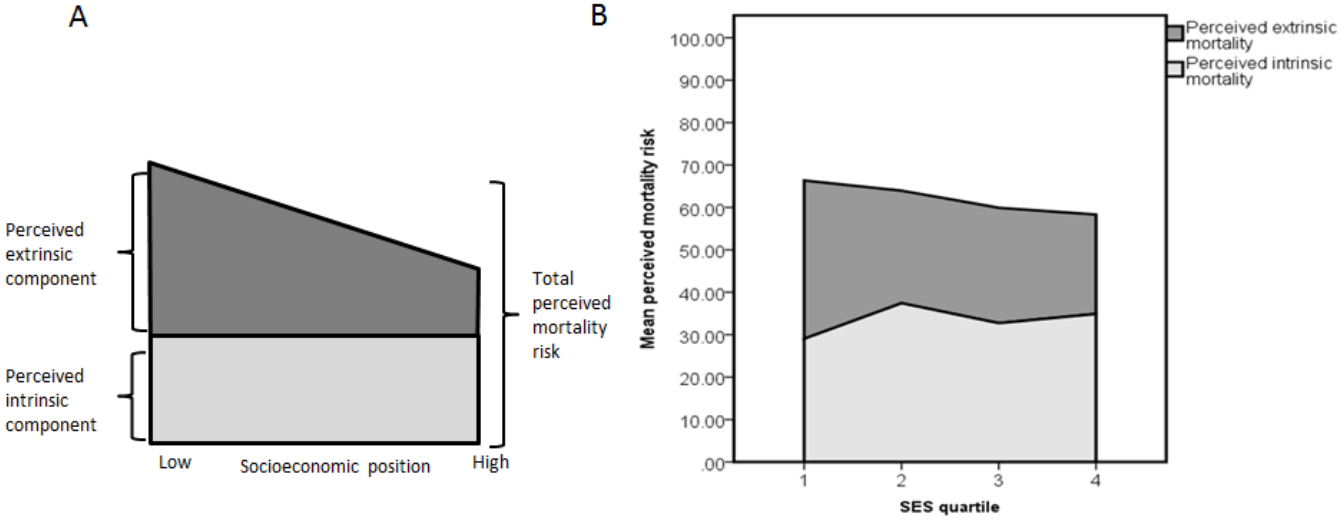

Fig 2. a: Predicted relationship between SEP and perceived mortality (arbitrary units). We predicted that it would be the perceived extrinsic mortality risk rather than the perceived intrinsic mortality risk that would show a social gradient. b: A plot of the actual relationship between SEP and perceived mortality with SEP split into quartiles based on the distribution of our data set.

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185 *Analysis*

186 We excluded 138 respondents who were under the age of 21, as measures of SEP are likely to be
187 unstable in participants younger than this age. We also excluded 22 individuals who spent less than
188 2 minutes completing the survey, the minimum possible time to engage with the questions
189 established by piloting; 1 individual whose reported income was more than 10 standard deviations
190 above the mean, and one individual whose sex was missing. This left a final sample of 438
191 respondents. We give details of the effect of these exclusions in the results section. We tested our
192 three predictions using General Linear Models (GLM) in SPSS version 19.0, with age and sex as
193 control variables in all cases. For prediction 3, we tested the statistical significance of mediation
194 with a Sobel test (Preacher & Hayes, 2004).

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Results

The raw data are available an online resource. Of the 438 respondents included in the analysis, 184 were male and 254 were female. Ages ranged from 21-72 years (mean 30.11 years, s.d. 9.65). Reported personal annual incomes ranged from $0 to $250,000 (untransformed mean $39,307, s.d. $38,888). Subjective SEP ranged from the minimum possible score of 3 to the maximum possible score of 21 (mean 11.11, s.d. 4.90).

Prediction 1: Association of SEP with perceived extrinsic and intrinsic mortality risk

We ran a multivariate GLM with perceived extrinsic and intrinsic mortality risk as the outcome variables, and income, subjective SEP, age and sex as the predictors. Subjective SEP was associated with perceived extrinsic mortality ($F_{1,419}$=6.86, p<0.01), with higher SEP associated with lower perceived extrinsic mortality (B=-0.84, s.e.[B]=0.32). Income was not associated with perceived extrinsic mortality ($F_{1,419}$=1.46, p=0.23). Neither subjective SEP ($F_{1,419}$=0.99, p=0.32) nor income ($F_{1,419}$=0.36, p=0.54) was significantly associated with perceived intrinsic mortality risk. (See table 1 for full model results). Thus our results conformed to the pattern predicted we predicted (see figure 2b).

		B	Standard error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
Age	**Perceived extrinsic mortality**	0.24	0.17	2.00	0.16	-0.09	0.58	0.005
Income		-0.02	0.02	1.46	0.23	-0.06	0.01	0.003
SEP		-0.84	0.32	6.86	0.01*	-1.47	-0.21	0.016
Sex		-2.39	3.03	0.62	0.43	-8.34	3.57	0.001
Age	**Perceived intrinsic mortality**	-0.33	0.16	4.38	0.04*	-0.63	-0.02	0.010
Income		0.01	0.02	0.39	0.54	-0.02	0.04	0.001
SEP		0.30	0.29	0.99	0.32	-0.29	0.87	0.002
Sex		2.20	2.77	0.63	0.43	-3.25	7.65	0.002

df=1, error =419, p = significance (*p<0.05), reference category for sex is male, effect size = η_p^2

Table 1. Predictors of perceived extrinsic and intrinsic mortality risk in a general linear model. SEP is a significant predictor of perceived extrinsic mortality risk and age is significant predictor of perceived intrinsic mortality risk.

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Prediction 2: Perceived extrinsic mortality and effort in looking after health

In a GLM with effort looking after health as the outcome variable and perceived extrinsic and intrinsic mortality risk along with age and sex as the predictors, both perceived extrinsic ($F_{1,417}$=230.36, p<0.01) and perceived intrinsic mortality risk ($F_{1, 417}$=3.98, p=0.05) were significantly associated with effort looking after health. Both associations were negative, with higher perceived mortality risk associated with lower effort (extrinsic: B=-0.63, s.e.[B]=0.04; intrinsic: B=-0.09, s.e.[B]=0.04). However, the association of health effort with perceived extrinsic mortality risk was much stronger than that with perceived intrinsic mortality risk. Perceived extrinsic mortality risk explained a substantial fraction of the variation not accounted for by other variables (η_p^2 = 0.36), and perceived intrinsic mortality risk explained very little of the variation not accounted for by other variables (η_p^2 = 0.01). (See table 2 for full model results).

	B	Standard error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
SEP	0.04	0.22	0.03	0.85	-0.38	0.46	0.00
Income	-0.01	0.01	0.33	0.57	-0.03	0.02	0.00
Perceived Extrinsic Mortality	-0.63	0.04	230.36	0.00*	-0.71	-0.55	0.36
Perceived Intrinsic Mortality	-0.09	0.05	3.98	0.05*	-0.18	0.00	0.01
Age	0.12	0.11	1.18	0.28	-0.10	0.35	0.00
Sex	-3.41	2.02	2.85	0.09	-7.39	0.56	0.01

df = 1, error = 417, p = significance (*p<0.05), reference category for sex is male, effect size = η_p^2

Table 2. Predictors of effort in looking after health in a general linear model with perceived mortality risk variables included. SEP is *not* a significant predictor of effort in looking after health, when perceived extrinsic mortality risk *is* included in the model.

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240 *Prediction 3: Mediation of the relationship between SEP and effort in looking after health by*
241 *perceived extrinsic mortality*

242 To test prediction 3, we followed the steps laid out by Baron and Kenny (Baron & Kenny, 1986) for
243 detecting mediation effects. First, we determined that subjective SEP was a significant predictor of
244 effort in looking after health, with age, sex and income controlled ($F_{1,433}$=3.94, p=0.05, B=0.56,
245 s.e.[B]=0.28, see table 3 for full model results). Second, we had already established that subjective
246 SEP was a predictor of extrinsic mortality perception (see Prediction 1 above). Finally, we added
247 perceived extrinsic mortality to the GLM predicting effort in looking after health from age, sex,
248 subjective SEP and income. We found that the relationship between SEP and health behaviour was
249 no longer significant ($F_{1,417}$=0.03, p=0.85), because perceived extrinsic mortality ($F_{1,417}$=230.36,
250 p<0.01) explained that variation. This suggests complete mediation (Baron & Kenny, 1986), a
251 conclusion supported by a significant Sobel test (z=2.71, p<0.01).

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	B	Standard Error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
SEP	0.56	0.28	3.94	0.05*	0.01	1.11	0.01
Income	0.01	0.02	0.32	0.57	-0.02	0.04	0.00
Age	-0.02	0.15	0.03	0.87	-0.32	0.27	0.00
Sex	-2.46	2.63	0.88	0.35	-7.63	2.70	0.00

258 df = 1, error = 433, p = significance (*p<0.05), reference category for sex is female, effect size = η_p^2

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260 **Table 3.** Predictors of effort in looking after health in a general linear model without perceived mortality risk included. SEP *is* a significant predictor of

261 effort in looking after health, when perceived extrinsic mortality risk is *not* included in the model.

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Effects of data exclusions on our results

In order to test whether the effect of SEP on health behaviour is mediated by perceived extrinsic mortality, we first had to ascertain whether there was an association between SEP and health effort in our data. This led us to exclude 138 respondents who were under the age of 21, because we felt that personal income would not be an accurate reflection of their actual SEP and parental income measures are often inaccurately reported (Boyce, Torsheim, Currie, & Zambon, 2006). We reran the main analyses without these exclusions. The association between SEP and health effort (controlling for age, sex and income) was now not statistically significant ($F(1,588)=1.77$, $p=0.18$, $\eta_p^2=0.003$). However, without the exclusions, perceived extrinsic mortality (controlling for age, sex, income and SEP) was still a significant predictor of health effort, with a large effect size ($F(1,587)=487.98$, $p<0.01$, $\eta_p^2 = 0.452$).

Conclusions

Our previously presented theoretical model (Nettle, 2010) led us to predict that conditions of high extrinsic mortality would trigger psychological mechanisms cause disinvestment in preventative health measures. We previously argued that this might explain the socioeconomic gradient in health behaviour, if people of lower SEP perceive themselves to be at greater risk of extrinsic mortality (Nettle, 2010; Pepper & Nettle, 2013). Here, we collected survey data to test key aspects of the model and its socioeconomic application. We found that there was a socioeconomic gradient in perceived mortality risk, with greater perceived risk amongst those of lower subjective SEP. Separating out the extrinsic and intrinsic components of this risk showed that it was entirely the extrinsic component of perceived risk which increased as SEP decreased, with no gradient in the intrinsic component (figure 2b). Perceived extrinsic mortality risk was strongly associated with reported effort in looking after health, whereas perceived intrinsic mortality risk was only weakly associated with it. We found that our subjective measure of SEP, but not income, was associated with reported effort in looking after health. However, this socioeconomic pattern was completely mediated by perceived extrinsic mortality risk. This suggests that people of lower subjective SEP make less effort to look after their health, but only because they perceive themselves to be subject to risks of mortality which are beyond their control.

These results are consistent with previous empirical findings that people of lower SEP tend to be more fatalistic about their health outcomes and have a greater belief in the influence of chance on their health than those of higher SEP (Wardle & Steptoe, 2003). However, they also demonstrate the benefits of taking an adaptively-informed approach to understand variation in human behaviour in the sphere of health. It was our *a priori* theoretical model (Nettle, 2010), based on previous behavioural ecological literature that suggested the potential importance of distinguishing extrinsic from intrinsic mortality, and predicted that it would be extrinsic mortality that motivated people to reduce their effort in looking after their health.

There are a number of limitations to the current study. We used an opportunity sample recruited through an online volunteer pool. It would be desirable to investigate whether the same patterns are found in population-representative samples. Our main SEP measures were income and a self-report scale. Income reporting in surveys is often inaccurate; disposable income, though more complex to assess, may be a better predictor of behaviour (Moore, Stinson, & Welniak, 2000; Winkler, Turrell, & Patterson, 2006). As for our self-report measure of SEP, it is simple to administer, but its relationship to more objective factors such as education and occupational status has not been explored here. The socioeonomic gradient in health effort was only detectable in our sample with the under-21 participants excluded from analysis. However, the existence of socioeconomic gradients in health behaviour is extremely well document in previously literature [1, 15], and the null association in our sample without exclusions may simply reflect the instability of self-reported income and SEP in participants who are not yet financially independent.

There are potential applied implications to our findings. They suggest that people of lower SEP may not make less effort to look after their health whimsically or through ignorance. Rather, they perceive that whatever they do, there is a relatively high chance that they will be killed anyway by something that they can do nothing about; so they follow a behavioural strategy of investing their resources in other things. Improving our understanding of what shapes perceived extrinsic mortality risk, and how to alter it, could therefore increase the efficacy of public health interventions. A number of psychological experiments have successfully manipulated factors such as time perspective using cues to extrinsic mortality, and time perspective has been related to a number of health behaviours (J Adams, 2009; Jean Adams & Nettle, 2009; Beenstock, Adams, & White, 2011; Brown & Adams, 2013; Callan, Willshead, & Olson, 2009; Griskevicius et al., 2011). However, to our knowledge there have been no direct tests of the impact of extrinsic mortality cues on actual health behaviours. It is important that such tests be developed.

The research presented here focused on *perceived* extrinsic mortality risk. However, relatively little is known about the environmental cues that produce these perceptions. Cues that

might contribute might include exposure to violent crime, or knowing people who have died due to circumstances beyond their control. Indeed, evidence suggests that fear of crime and experiences of bereavement are associated with poor health (Chandola, 2001; Stafford, Chandola, & Marmot, 2007; Stroebe, Schut, & Stroebe, 2007). It would be useful to understand to what extent such cues contribute to a person's perceived extrinsic mortality risk and whether qualitative differences between cues are important. It would also be useful to know how accurate people's perceptions of mortality risk are. There is some epidemiological evidence that suggests that actual as well as perceived extrinsic mortality risk is higher in low-SEP communities (Bolte, Tamburlini, & Kohlhuber, 2010; Soskolne & Mano, 2010). However, although there may be a veridical basis to excess extrinsic mortality risk, its perception may be inflated by media scare stories or by exaggerated accounts from peers. If this is the case, then something as simple as correcting people's perceptions may be enough to improve their health behaviours. However, this is not to understate the fundamental importance of public action to tackle the sources of extrinsic mortality that differentially affect those of lower SEP. Making low SEP neighbourhoods and work places safer would not only have the primary benefit of reducing extrinsic mortality, but it could also produce a secondary benefit of improved health behaviours. This would have the overall effect of reducing socioeconomic inequalities in health.

346 **Supplementary data.** The supplementary .xls file contains the raw data in Microsoft Excel format.

347 The first tab of the .xls file contains descriptions of each variable and further read me information.

348 **Conflict of interest**: We declare that we have no conflict of interest.

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476