Being Poor and Coping With Stress: Health Behaviors and the Risk of Death

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Objectives. Individuals may cope with perceived stress through unhealthy but often pleasurable behaviors. We examined whether smoking, alcohol use, and physical inactivity moderate the relationship between perceived stress and the risk of death in the US population as a whole and across socioeconomic strata.

Methods. Data were derived from the 1990 National Health Interview Survey's Health Promotion and Disease Prevention Supplement, which involved a representative sample of the adult US population (n = 40 335) and was linked to prospective National Death Index mortality data through 1997. Gompertz hazard models were used to estimate the risk of death.

Results. High baseline levels of former smoking and physical inactivity increased the impact of stress on mortality in the general population as well as among those of low socioeconomic status (SES), but not middle or high SES.

Conclusions. The combination of high stress levels and high levels of former smoking or physical inactivity is especially harmful among low-SES individuals. Stress, unhealthy behaviors, and low SES independently increase risk of death, and they combine to create a truly disadvantaged segment of the population. (*Am J Public Health.* 2008;98:889–896. doi:10.2105/AJPH.2007.114454)

Perceived stress is a negative affective state that individuals may attempt to relieve or cope with through unhealthy but often pleasurable behaviors.[1–9] High levels of perceived stress are associated with smoking initiation, increased smoking levels, less successful smoking cessation attempts, drinking alcohol more often and in heavier quantities, increased problem drinking, and reports of positive attitudes toward drinking.[4,10–23] Some people exercise to control their stress,[24] but most individuals respond to stress by exercising less frequently and at lower levels because sedentary behavior is more rewarding in the short term.[4,10,23,25]

Stress and unhealthy behaviors each increase the risk of death.[15,26–36] Numerous social stressors and high levels of perceived stress have been shown to be positively associated with mortality.[15,26] Current and former smoking and physical inactivity are also positively associated with mortality.[27–32] Alcohol consumption has a J-shaped relationship with mortality; abstainers and heavy drinkers are at increased risk of death relative to moderate drinkers.[29,33–36] To our knowledge, no research has examined whether unhealthy behaviors moderate the relationship between stress and mortality.

Our first aim in this study was to examine whether unhealthy behaviors moderate the stress–mortality relationship in a nationally representative sample of US adults. There are 3 possible relationships between stress, health behaviors, and the risk of death. First, the "double jeopardy" perspective suggests that multiple risk factors combine to increase the risk of death more than a single risk factor alone would indicate.[37,38] Smoking, alcohol use, and physical inactivity may be pleasurable but deleterious strategies for coping with perceived stress, and they may inadvertently increase the effects of stress on mortality.[39,40] Second, unhealthy behaviors may allow individuals to cope effectively with stress.[3,5,7,8,41] Unhealthy behaviors and high stress levels are each associated with increased mortality, but unhealthy behaviors may nevertheless reduce the effects of stress on mortality. Finally, the null hypothesis implies that unhealthy behaviors will not moderate the stress–mortality relationship.

Our second aim was to examine whether unhealthy behaviors moderate the impact of stress on mortality differently across different socioeconomic strata. The social vulnerability hypothesis suggests that the combination of unhealthy behaviors and high stress levels may be particularly risky among individuals of low socioeconomic status (SES), who might be more vulnerable, or less resilient, to accumulating health risks.[42,43] Those who are less advantaged "experience multiple threats to their health, with each threat making the other more serious."[43(p302)]

By contrast, the "Blaxter hypothesis" posits that unhealthy behaviors may be less harmful among those in low-SES groups, precisely because members of these groups already face numerous insults resulting from unsafe housing, work, and neighborhood environments.[44] Improving unhealthy behaviors without ameliorating underlying socioeconomic disadvantages may yield few health benefits.[3,45–47] Thus, if unhealthy behaviors increase the relationship between stress and mortality, their influence may be attenuated among low-SES individuals.

METHODS

We used data from the 1990 National Health Interview Survey's Health Promotion and Disease Prevention Supplement, in which in-person interviews were conducted with a nationally representative sample of the noninstitutionalized US population 18 years or older.[48,49] Data from the supplement were linked to prospective National Death Index mortality data through December 1997 by matching 12 respondent characteristics (Social Security number; first and last names; middle initial; race; gender; marital status; day, month, and year of birth; and state of birth and residence) to death records.[50]

We eliminated from our sample records that could not be linked to the National Death Index as a result of missing information on matching characteristics (1.9%), which yielded 40 335 respondents, of whom 3441 had died. Survival duration indicated the number of months between the date on

which individuals were interviewed and the date of their death (among those who had died) or the end of the follow-up period (among those who had survived).

Variables and Measurement

We used 2 questions to assess perceived stress. The first asked, "During the past 2 weeks, would you say that you experienced a lot of stress, a moderate amount of stress, relatively little stress, or almost no stress at all?" The second question asked about the "past year" rather than the "past 2 weeks." Participants responded on a scale ranging from 1 to 4. These items captured the subjective dimensions of stress that may affect health behaviors and avoided focusing on specific stressors that might be irrelevant for some people. They have reasonable face validity because they ask directly about stress perceptions, and they have reasonable construct validity in that their associations with mortality and SES are consistent with the associations shown in previous research.

We created a stress index by taking the mean of the 2 items, standardizing the resulting variable so that we could interpret our results in terms of stress index standard deviations, and adding a constant to set the minimum value to 0 so that higher values indicated higher stress (maximum value=3.2). We created an index rather than including the items separately, because the items were highly correlated (r=0.71) and each item exhibited similar relationships with the other variables of interest (data not shown).

The Health Promotion and Disease Prevention Supplement asked about current and former smoking levels among individuals who reported that they had ever smoked 100 or more cigarettes. Current smokers were classified according to the number of packs they smoked each day (calculated as number of cigarettes smoked divided by 20). Former smokers were classified according to the number of packs they had smoked each day before they quit. The variables for current and former smoking were coded as 0 for individuals who had never smoked (the referent group).

The drinking variable, scores for which ranged from 0 (including those who abstained) to 12 or more, indicated how many alcoholic drinks respondents consumed on days they drank. We tested different functions for the relationship between drinking and mortality (see Greenland[51]) by raising the drinking variable to all combinations of 2 of the following powers: 0.5, 1.0, 1.5, and 2.0. Raising the drinking variable to the powers of 0.5 and 1.0 best captured the J-shaped relationship between drinking and mortality, as indicated by improvements in model fit, but our final results were similar across all of the transformations we tested.

We assessed physical inactivity with an index that summed standardized values of 3 items (α=0.67): whether individuals reported exercising or playing sports regularly (yes or no), how many years they reported having exercised regularly (range=0–98), and whether they reported being more active than, about as active as, or less active than others their age (range=1–3). We created an index because each item exhibited similar relationships with stress and mortality. Higher values indicated more inactivity, and we added a constant to give the index a minimum value of 0 (maximum=4.3). We calculated interactions by multiplying the health behavior variables by the stress index.

We adjusted for socioeconomic and demographic factors that are key predictors of prospective mortality.[32,52] The years of education variable was continuous and ranged from 0 to 18 or more. Family income was reported in 27 categories ranging from less than $1000 to $50 000 or more. We approximated a continuous income measure by taking the midpoint of categories under $50 000 and estimating a median value of $68 645 for the open-ended income category of $50 000 or more (as done elsewhere[53]). Family income was divided by 10 000 and logged to account for the diminished impact of each additional unit of income on mortality as income increases.[32] Age was assessed in decades ranging from 1.8 to 9.9 or above. Men were coded as 1 and women as 0. Race/ethnicity categories included non-Hispanic White (the referent), non-Hispanic Black, Hispanic, and "other." Marital status included currently married (the referent), previously married, and never married.

We stratified by SES to create 3 groups: low-SES individuals (12 or fewer years of education and an annual family income below $20 000 at baseline), middle-SES individuals (12 or fewer years of education and an annual family income of $20 000 or above or more than 12 years of education and an annual family income below $20 000 at baseline), and high-SES individuals (more than 12 years of education and an annual family income of $20 000 or more at baseline). These cut points were close to the median education (51.9% of the sample had 12 or fewer years of education) and income (41.2% of the sample had a family income below $20 000) values. We used a general 2-category income variable (less than $20 000 per year vs $20 000 or more per year; data were missing for only 1.6% of the respondents) rather than the more detailed family income measure (for which data were missing for 17% of respondents) to minimize error in determining respondents' SES.

Classifying individuals according to both education and income allowed us to identify those who were most and least advantaged according to 2 key SES dimensions. Education is often established early in life, before the onset of age-related poor health, and is associated with future economic resources and knowledge about health maintenance strategies.[54] Family income captures the resources that individuals can access in times of need, is less sensitive than personal earnings to people's bouts of poor health, and is applicable for those who rely on the earnings of others.[32,52] Analyses that stratified by income only or by education only produced similar but attenuated results (data not shown), probably because they less completely captured socioeconomic advantage or disadvantage.

Statistical Analysis

In the case of most variables, data were missing for fewer than 3% of the respondents, although information on the detailed family income measure was missing for 17% of the respondents. We used multiple imputation to create 5 complete data sets, each with different imputed values for the missing data.[55] The imputed values were drawn from the posterior predictive distribution estimated from variables that were associated with missing data.[56]

Multiple imputation assumes that values are missing at random after conditioning on

observed variables; this assumption is not testable, but it becomes more tenable when a large number of variables are used to predict missing values.[57] We used more than 70 variables—including the less detailed family income measure—to create our imputations. If our imputation model were to poorly estimate the missing values, then there would be greater variation across the imputed data sets, leading to larger standard errors reflecting our uncertainty about the missing values.[55,57,58] We combined the results from the imputed data sets and used the F test to compare improvements in model fit (as described elsewhere[55,58]).

Because adult mortality increases exponentially with age,[59] we used Gompertz proportional hazard models to examine the risk of death among adults.[60,61] The Gompertz model is parameterized as follows:

$$h(t) = exp\{a + b_i x_i + \gamma t\}, \quad (1)$$

where a is a constant, x_i is a variable in the model, b_i is the unstandardized parameter estimate for that variable, and γ is an ancillary parameter, estimated from the data, that indicates the change in the hazard over time. Hazard of death, given as follows, was the dependent variable:

$$h(t) = \lim_{s \to 0} P(t, t+s) / s, \quad (2)$$

where P is the probability that death will occur in an interval from t to $t + s$, given that the individual was at risk at time t. This probability is divided by s, the length of the interval; s becomes smaller until the ratio reaches a limit. On the basis of improvements in the Akaike information criterion,[60,62] the Gompertz model fit the data significantly better than Cox, Weibull, or exponential models. Nevertheless, all specifications provided virtually identical estimates for the coefficients of interest.

In all analyses, the svy commands in Stata were used to incorporate sample weights and estimate standard errors with the Taylor linearized variance estimator that accounted for the stratified, single-stage sampling frame.[49,63] The Gompertz model estimated γ separately in each of the sample's 62 strata; we do not present these coefficients because they were not central to our analyses. We used the Holm method to adjust P values for the increased probability of making a type I error when including variables with multiple categories in our multivariate models (as described elsewhere[64]).

TABLE 1—Weighted Covariate Means and Proportions Among US Adults, by Vital Status and Socioeconomic Status (SES): 1990–1997

	Vital Status[a]			SES[b]			
	Survived	Died	P[c]	Low	Middle	High	P[c]
Unweighted total, no.	36 894	3 441		12 193	13 182	14 960	
Stress and health behaviors							
Perceived stress score, mean	1.85	1.42	<.001	1.60	1.78	1.97	<.001
Smoking			<.001				<.001
Packs smoked per day among current smokers, mean	0.24	0.25		0.29	0.27	0.18	
Packs smoked per day among former smokers, mean	0.27	0.48		0.25	0.28	0.30	
No history of smoking, proportion	0.51	0.39		0.47	0.47	0.54	
No. of alcoholic drinks per day, mean	1.45	0.96	<.001	1.23	1.52	1.43	<.001
Physical inactivity index score, mean	3.27	3.42	<.001	3.47	3.31	3.13	<.001
Socioeconomic characteristics							
Education, y, mean	13.4	11.8	<.001	10.5	12.4	15.6	<.001
Family income, $, mean	35 049	23 526	<.001	11 380	32 250	49 180	<.001
Demographic characteristics							
Age, y, mean	41.9	67.5	<.001	49.5	42.2	41.8	<.001
Gender (male = 1), proportion	0.47	0.53	<.001	0.41	0.48	0.51	<.001
Race/ethnicity, proportion			<.001				<.001
Non-Hispanic White	0.78	0.83		0.67	0.79	0.84	
Non-Hispanic Black	0.11	0.12		0.19	0.10	0.07	
Hispanic	0.08	0.04		0.12	0.08	0.05	
Other	0.03	0.02		0.02	0.03	0.04	
Marital status, proportion			<.001				<.001
Currently married	0.65	0.57		0.48	0.65	0.75	
Previously married	0.15	0.36		0.33	0.15	0.09	
Never married	0.19	0.07		0.20	0.21	0.16	
Survival							
Overall mortality (died = 1), proportion	0.00	1.00		0.15	0.06	0.04	<.001
Duration, mo, mean	89.4	48.0	<.001	83.0	87.0	87.8	<.001

[a]Vital status was assessed through the end of 1997.
[b]Low SES = 12 or fewer years of education and family income below $20 000; middle SES = more than 12 years of education and family income below $20 000, or 12 or fewer years of education and family income of $20 000 or more; high SES = more than 12 years of education and family income of $20 000 or more.
[c]From the Wald test accounting for the complex sampling frame used in the Health Promotion and Disease Prevention Supplement. In all cases, the null hypothesis was that the distribution of each variable would be the same according to vital status and according to SES.

RESULTS

Table 1 presents covariate means and proportions by vital status and SES. Individuals who survived the follow-up period had an average perceived stress index score of 1.85 at baseline; decedents had lower baseline stress levels (mean score = 1.42). Among survivors, current smokers reported smoking a mean of 0.24 packs per day at baseline, and former smokers reported smoking a mean of 0.27 packs per day; among decedents, the corresponding means were 0.25 and 0.48. Means for dichotomous variables were proportions; the proportion of individuals reporting at baseline that they had never smoked was 0.51 among survivors but only 0.39 among decedents. Survivors drank more alcohol and were less physically inactive at baseline than

decedents. Perceived stress scores, former smoking levels, and the proportion of respondents who reported no history of smoking increased with increasing SES, and levels of current smoking and physical inactivity declined with increasing SES.

Table 2 presents results from the Gompertz hazard models for the risk of death in the US adult population as a whole. Model 1 included variables for stress, health behaviors, SES characteristics, and demographic characteristics and revealed a positive relationship between perceived stress and mortality. The first hazard ratio shows that a stress index increase of 1 standard deviation was associated with a 5% increase in the risk of death. Among current smokers, each additional pack of cigarettes smoked per day (as reported at baseline) was associated with a 55% increase in the risk of death relative to never smokers; among former smokers, the corresponding increase was 14%.

The number of alcoholic drinks consumed per day exhibited a curvilinear relationship with mortality. Calculations based on model 1 showed that, in comparison with individuals who reported at baseline that they abstained from drinking, those who consumed 3 drinks per day had 0.85 times the risk of death (95% confidence interval [CI]=0.75, 0.96), and those who consumed 12 or more drinks per day had 1.39 times the risk of death (95% CI=1.04, 1.85). Physical inactivity at baseline was positively associated with mortality.

Model 2 included interactions between health behaviors and perceived stress in addition to the variables in model 1. The interaction between current smoking at baseline and stress was not significant, but high former smoking levels increased the relationship between stress and the risk of death. Drinking did not moderate the stress–mortality relationship. High levels of physical inactivity increased the impact of stress on mortality. The note in Table 2 shows that model 2 did not fit the data better than model 1; however, a model (data not shown) that included all of the variables from model 2 other than the interactions between stress and drinking did provide a better fit than model 1 ($F_{3,86.5}=2.98$, $P=.036$).

Table 3 presents results from Gompertz hazard models stratified according to SES; all models adjusted for age, gender, race/ethnicity, and marital status (coefficients are not shown). The top portion shows that perceived stress at baseline was positively associated with the risk of death among those in the high- but not the low- or middle-SES groups. The coefficient for perceived stress was greater among high-SES individuals than among low-SES ($z=2.42$; $P=.016$) or middle-SES ($z=2.92$; $P=.004$) individuals (methods described elsewhere[65]). Across all 3 strata, high baseline

TABLE 2—Unstandardized Parameter Estimates and Hazard Ratios (HRs) From Gompertz Hazard Models of the Risk of Death Among US Adults: 1990–1997

	Model 1		Model 2	
	b (SE)	HR	b (SE)	HR
	Stress and health behaviors			
Perceived stress	0.047** (0.018)	1.05	–0.060 (0.148)	0.94
Smoking				
Packs smoked per day among current smokers	0.438** (0.042)	1.55	0.377** (0.083)	1.46
Packs smoked per day among former smokers	0.128** (0.038)	1.14	0.081 (0.049)	1.09
No history of smoking	Reference		Reference	
Stress by packs smoked per day among current smokers			0.036 (0.032)	1.04
Stress by packs smoked per day among former smokers			0.033* (0.016)	1.03
Alcohol consumption[a]				
(No. of drinks)$^{0.5}$	–0.703** (0.165)	0.50	–0.446* (0.180)	0.64
(No. of drinks)$^{1.0}$	0.180** (0.038)	1.20	0.115** (0.032)	1.12
Stress by (No. of drinks)$^{0.5}$			–0.162 (0.150)	0.85
Stress by (No. of drinks)$^{1.0}$			0.042 (0.038)	1.04
Physical inactivity				
Physical inactivity index	0.266** (0.029)	1.31	0.182** (0.048)	1.20
Stress by physical inactivity index			0.062* (0.029)	1.06
	Socioeconomic characteristics			
Education, y	–0.022** (0.007)	0.98	–0.022** (0.007)	0.98
Ln(family income/$10 000)	–0.153** (0.056)	0.86	–0.151** (0.056)	0.86
	Demographic characteristics			
Age, y/10	0.826** (0.026)	2.28	0.825** (0.026)	2.28
Gender (male = 1)	0.605** (0.046)	1.83	0.602** (0.044)	1.83
Race/ethnicity				
Non-Hispanic White	Reference		Reference	
Non-Hispanic Black	0.149* (0.056)	1.16	0.149* (0.055)	1.16
Hispanic	–0.266** (0.084)	0.77	–0.273** (0.089)	0.76
Other	–0.293 (0.215)	0.75	–0.296 (0.217)	0.74
Marital status				
Currently married	Reference		Reference	
Previously married	0.118* (0.050)	1.13	0.118* (0.051)	1.13
Never married	0.225** (0.043)	1.25	0.228** (0.046)	1.26
Constant	–11.96** (0.349)		–11.84** (0.171)	

Note. The gamma coefficients indicating the change in the baseline hazard of death over the follow-up period within each of the 62 strata of the Health Promotion and Disease Prevention Supplement are not shown. Model 2 vs model 1: $F_{5,61.5}=1.88$; $P=.11$. We used the Holm method to adjust P values for the increased risk of type-I error associated with conducting multiple tests simultaneously.

[a]Number of drinks consumed raised to the power of 0.5 and 1.0.

*$P<.05$; **$P<.01$ (2-tailed).

TABLE 3—Unstandardized Parameter Estimates and Hazard Ratios (HRs) From Gompertz Hazard Models of the Risk of Death Among US Adults, by Socioeconomic Status (SES): 1990–1997

	Low SES		Middle SES		High SES	
	b (SE)	HR	b (SE)	HR	b (SE)	HR
Stress and health behaviors						
Perceived stress	0.039 (0.022)	1.04	0.008 (0.028)	1.01	0.135** (0.033)	1.14
Smoking						
Packs smoked per day among current smokers	0.412** (0.047)	1.51	0.404** (0.066)	1.50	0.497** (0.066)	1.64
Packs smoked per day among former smokers	0.154** (0.037)	1.17	0.109* (0.052)	1.12	0.098 (0.058)	1.10
No history of smoking	Reference		Reference		Reference	
Alcohol consumption[a]						
(No. of drinks)$^{0.5}$	−0.597 (0.317)	0.55	−0.424** (0.148)	0.65	−1.406** (0.477)	0.25
(No. of drinks)$^{1.0}$	0.119 (0.071)	1.13	0.123** (0.030)	1.13	0.391** (0.120)	1.48
Physical inactivity index	0.336** (0.057)	1.40	0.217** (0.047)	1.24	0.216** (0.033)	1.24
Stress, health behaviors, and interactions						
Perceived stress	−0.223 (0.220)	0.80	−0.129 (0.367)	0.88	0.252 (0.389)	1.29
Smoking						
Packs smoked per day among current smokers	0.447** (0.128)	1.56	0.213 (0.152)	1.24	0.385* (0.146)	1.47
Packs smoked per day among former smokers	0.106* (0.042)	1.11	0.083 (0.096)	1.09	0.035 (0.099)	1.04
No history of smoking	Reference		Reference		Reference	
Stress by packs smoked per day among current smokers	−0.022 (0.058)	0.98	0.117 (0.074)	1.12	0.058 (0.083)	1.06
Stress by packs smoked per day among former smokers	0.034* (0.016)	1.03	0.017 (0.064)	1.02	0.039 (0.053)	1.04
Alcohol consumption[a]						
(No. of drinks)$^{0.5}$	−0.215 (0.165)	0.81	−0.468 (0.526)	0.63	−0.987 (0.842)	0.37
(No. of drinks)$^{1.0}$	0.001 (0.023)	1.00	0.167 (0.122)	1.18	0.292 (0.158)	1.34
Stress by (No. of drinks)$^{0.5}$	−0.239 (0.138)	0.79	0.027 (0.384)	1.03	−0.238 (0.351)	0.79
Stress by (No. of drinks)$^{1.0}$	0.074 (0.045)	1.08	−0.028 (0.085)	0.97	0.057 (0.075)	1.06
Physical inactivity						
Physical inactivity index	0.187 (0.103)	1.21	0.176 (0.114)	1.19	0.191 (0.120)	1.21
Stress by physical inactivity index	0.119* (0.057)	1.13	0.034 (0.088)	1.03	0.018 (0.063)	1.02
Test: bottom stress and health model vs top stress, health, and interaction model	$F_{5,136} = 2.29$; $P = .049$		$F_{5,52} = 0.99$; $P = .435$		$F_{5,3445} = 0.34$; $P = .887$	

Note. All models were also adjusted for age, gender, race/ethnicity, and marital status (parameter estimates not shown). Low SES = 12 or fewer years of education and a family income below $20 000; middle SES = more than 12 years of education and a family income below $20 000, or 12 or fewer years of education and a family income of $20 000 or more; high SES = 12 years of education and a family income of $20 000 or more. The gamma coefficients indicating the change in the baseline hazard of death over the follow-up period within each of the 62 strata of the Health Promotion and Disease Prevention Supplement are not shown. We used the Holm method to adjust *P* values for the increased risk of type I error associated with conducting multiple tests simultaneously.

[a]Number of drinks consumed raised to the power of 0.5 and 1.0.

*$P < .05$; **$P < .01$ (2-tailed).

levels of current smoking and physical inactivity were associated with increased mortality, high former-smoking levels were associated with increased mortality among individuals in the low- and middle-SES groups, and high levels of alcohol use in terms of drinks consumed per day were associated with mortality among individuals in the middle- and high-SES groups.

The models shown in the bottom panel of Table 3 also included interactions between perceived stress and the health behaviors assessed. Among low-SES individuals, former smoking and physical inactivity at baseline increased the impact of stress on mortality. The number of drinks consumed per day did not moderate the relationship between stress and mortality. None of the interactions between stress and the health behaviors achieve statistical significance among middle- or high-SES individuals. The final row of Table 3 shows that the model with interactions (bottom panel) fit better than the reduced model (top panel) among low-SES but not middle- or high-SES individuals.

DISCUSSION

With respect to the first aim of this study—examining whether unhealthy behaviors moderate the stress–mortality relationship in a nationally representative sample of US adults—results showed that physical inactivity and

former smoking at baseline increased the impact of stress on mortality. Our findings are consistent with the "double jeopardy" perspective, according to which multiple risk factors (we focused on perceived stress and unhealthy behaviors; others have examined different risk factors) combine to increase the risk of death more than any of the risk factors in isolation would indicate.[37–40] Engaging in unhealthy but pleasurable behaviors is a poor strategy for coping with high perceived stress[3,5,7,8] because these behaviors may increase stress levels[39,40] and, as shown here, because they increase the impact of stress on mortality. However, consumption of alcohol did not moderate the stress–mortality relationship.

In terms of the study's second aim—examining whether unhealthy behaviors moderate the stress–mortality relationship differently across different socioeconomic strata—high levels of former smoking or physical inactivity at baseline increased the impact of perceived stress on mortality among low-SES but not middle- or high-SES individuals. This result supports the social vulnerability hypothesis: low-SES individuals are especially disadvantaged by the combination of unhealthy behaviors and high perceived stress, possibly because they have fewer resources to maintain their health or effectively cope with stress.[42,43] By contrast, unhealthy behaviors did not reduce the effect of stress on mortality among low-SES individuals.[3,44,46,47]

The support we found for the social vulnerability hypothesis suggests that interventions that help people cope with stress effectively or undertake healthier behaviors—especially avoiding smoking or increasing physical activity—could benefit low-SES individuals. However, the least healthy behaviors are often found among those with the fewest socioeconomic resources.[3,21,26,45,66–68] Interventions that aim to reduce mortality among vulnerable populations might be most effective if they simultaneously target socioeconomic disadvantage, unhealthy behaviors, and ineffective stress management strategies.

Additional analyses (data not shown) further bolstered our findings. First, the results in Table 3 were unchanged after adjustment for the detailed income and education variables, and the coefficients for the detailed socioeconomic variables were often nonsignificant. Second, there were age differences in socioeconomic attainment (Table 1), and older individuals may have had more years of exposure to the risk factors. We ran the models shown in Table 3 separately for respondents aged 19 to 60 years (those who were aged 18 years were still very likely to finish high school, a major stratification criterion) and those 61 years or older and found similar results across age groups.

Strengths and Limitations

The strengths of our study included the use of nationally representative US data incorporating a large number of deaths over a 7-year follow-up period. Multiple imputation methods allowed us to make use of information on variables for which there were no missing data in estimating our models, and these methods relied on weaker (i.e., more plausible) assumptions than the often used method of deleting all observations with missing values on any covariate.[55,58] In addition, multiple imputation more accurately accounts for uncertainty about missing values than conditional mean or hot-deck imputation methods[55,57] and is often robust to violations of the assumption that values are missing at random.[69]

Our study involved several limitations. First, our perceived stress index has not been used previously. However, the index compared favorably with measures used elsewhere. Table 1 shows that SES and perceived stress were positively associated (see also Heslop et al.,[18] Grzywacz et al.,[70] and Schieman et al.[71]), although some research has revealed an inverse relationship between stress and SES.[26] Model 1 in Table 2 showed that perceived stress was positively associated with mortality, as others have found with various health and mortality outcomes,[15,26,70] although some research has not shown a relationship between stress and cardiovascular health outcomes.[18] Previous studies have not assessed interactions between stress and health behaviors in the full population or according to SES, the major contribution of our work.

Our stress index was not associated with mortality after the inclusion of interactions between stress and health behaviors (Table 2, model 2), suggesting that stress had the greatest association with mortality among former smokers or more-inactive individuals. There is a need for future work replicating our findings with different data, with alternate stress measures, and for specific causes of death.

Second, our baseline data were cross sectional, and thus we were not able to assess the temporal ordering of stress and health behaviors. Although our data addressed stress over the course of a year and health behaviors often established early in life, individuals' perceptions of stress, behaviors, or socioeconomic status may not be recalled accurately and might change over a follow-up period. Future research could examine the dynamic relationship between perceived stress and unhealthy behaviors over time.

Third, our health behavior variables did not capture all dimensions of the behaviors in question. However, additional analyses (data not shown) excluding former smokers who smoked only occasionally or who had quit in the past 2 months and were likely to resume smoking produced identical results. Furthermore, the number of drinks respondents consumed per day was a better predictor of mortality than was number of days they had consumed alcohol in the preceding 2 weeks or total number of drinks they had consumed in the past 2 weeks. The increased mortality among abstainers persisted after exclusion of those who abstained for health reasons or because they were alcoholic.

Finally, although our data did not include objective measurements of physical activity, our index allowed us to distinguish between individuals who were the most active and those who were the least active. Importantly, according to the results of previous research, our health behavior measures were associated with mortality in the expected direction.

Public Health Implications

Stress and unhealthy behaviors are types of disadvantage that reduce survival most among those with the fewest socioeconomic resources.[37,38] Not only do they have independent relationships with mortality, but stress, unhealthy behaviors (especially former smoking and physical inactivity), and low SES combine to increase mortality and to form a truly disadvantaged segment of the population. ■

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This article was accepted September 1, 2007.

Contributors

Both authors participated in study conceptualization and design, as well as interpretation of findings. P.M. Krueger completed the analyses and led the writing. V.W. Chang contributed to analytic design and to the writing of the article.

Acknowledgments

We acknowledge research and administrative support from the Robert Wood Johnson Health and Society Scholars Program at the University of Pennsylvania, the National Institutes of Health (National Institute of Child Health and Human Development [NICHD] grant K12-HD043459), and the University of Texas Population Research Center (NICHD grant R24-HD42849).

An earlier version of this article benefited from the insightful comments of Luisa Franzini, Robert Hummer, and Richard Rogers.

Human Participant Protection

This study was approved by the institutional review boards of the University of Texas and the University of Pennsylvania.

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