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Perceived Stress and Mortality in a Taiwanese Older Adult Population

Sarinnapha Vasunilashorn, PhD, Dana A. Gleib, PhD, Maxine Weinstein, PhD, and Noreen Goldman, DSc

Office of Population Research (S.V., N.G.), Princeton University, Princeton, New Jersey; and the Center for Population and Health (D.A.G., M.W.), Georgetown University, Washington, District of Columbia

Abstract

Perceived stress is associated with poor health outcomes including negative affect, increased susceptibility to the common cold, and cardiovascular disease; the consequences of perceived stress for mortality, however, have received less attention. This study characterizes the relationship between perceived stress and 11-year mortality in a population of Taiwanese adults aged 53+. Using the Survey of Health and Living Status of the Near Elderly and Elderly of Taiwan, we calculated a composite measure of perceived stress based on six items pertaining to the health, financial situation, and occupation of the respondents and their families. Proportional hazard models were used to determine whether perceived stress predicted mortality. After adjusting for sociodemographic factors only, we found that a one standard deviation increase in perceived stress was associated with a 19% increase in all-cause mortality risk during the 11-year follow-up period (HR=1.19, 95% CI 1.13–1.26). The relationship was greatly attenuated when perceptions of stress regarding health were excluded, and was not significant after adjusting for medical conditions, mobility limitations, and depressive symptoms. We conclude that the association between perceived stress and mortality is explained by an individual's current health; however, our data do not allow us to distinguish between two possible interpretations of this conclusion: a) the relationship between perceived stress and mortality is spurious, or b) poor health acts as the mediator.

Keywords

perceptions; aging; health; death; perceived stress; all-cause mortality

INTRODUCTION

The impact of an event is partly determined by an individual's interpretation of how stressful it may be (Lazarus 1966, 1977). This perception plays an important role in the emotional and physiological responses that ensue (Goldman et al. 2005). Cohen et al. (1997) proposed a theoretical model that links the experience of stressors (e.g., environmental demands and

life events) to physiological and behavioral responses. This model presents the stress process as a sequence of steps in which events lead to either a benign appraisal or to the perception of stress. In the former case, no stress response is elicited. In the latter case, perceived stress results in negative emotional responses, which in turn lead to a physiological or behavioral response. Hence, crucial points in this pathway are the individual's appraisal of the demands inflicted by the events or stressors and his/her adaptive capacities (e.g., the availability of coping resources). In this view, it is the cognitively mediated emotional response to the life event, not the event itself, which leads to the behavioral or physiological responses (Lazarus 1977; Mason, 1971). The importance of this insight is underscored by variations in the assessment of stressors, and these variations may be influenced by multiple factors, including personal experiences, personality, coping mechanisms, and social support (Biondi and Picardi 1999; Schwartz et al. 1996). Currently, the psychological processes solicited by a stressor are thought to bridge the concepts of stress exposures and stress responses (e.g., perceptions of stress) (Van Praag et al. 2004).

While most studies that have examined stress and disease (or mortality) use the occurrence of 'objective' stressful events (e.g., death of a spouse) to assess these associations, the links between perceptions of stress and mortality have received much less attention. Our study aimed to address the question: is perceived stress predictive of mortality in a population of older Taiwanese adults? Among the few previous studies of perceived stress and mortality, the findings have been mixed. On the one hand, perceptions of high levels of stress were not predictive of all-cause mortality in a Scottish population (Macleod et al. 2001). On the other hand, high appraisal of stress was associated with a greater risk of all-cause mortality among South Koreans and Danes (Khang and Kim 2005; Nielsen et al. 2008). We hypothesized that our study of older Taiwanese adults would reveal an association between perceived stress and mortality, such that higher perceptions of stress and chronic reports of perceived stress would predict greater mortality. We also hypothesized that the link between perceived stress and cardiovascular and cancer-related mortality would be especially pronounced given the association between perceived stress and these conditions (Dimsdale, 2008).

METHODS

Study Population

We used data from the Survey of Health and Living Status of the Near Elderly and Elderly (or Taiwan Longitudinal Study of Aging [TLSA]), a nationally representative random sample of adults in Taiwan. The oldest cohort was comprised of 4,049 respondents (ages 60+ years) who were first interviewed in 1989; in 1996, 2,462 participants (ages 50–66 years) were added. Follow-up interviews were conducted with both cohorts in 1999 (n=4,440; 90% of survivors), 2003 (n=3,777; 92% of survivors), and 2007 (n=4,534; 90% of survivors; Chang and Hermalin, 1998a, 1998b; Hermalin et al 1989). The participant's native language (Mandarin, Taiwanese, or Hakka) was used for the interview with the study participants. Several bilingual individuals provided translations of the Chinese questionnaires into English.

In this study, we used interview data from 1999, 2003, and 2007 and survival status through 2010. Survival status (as of December 31, 2010) and date of death were obtained by linking

the survey data to death certificate files maintained by the Taiwan Department of Health and to the household registration file from the Taiwanese Ministry of the Interior. Linkage of one database to another creates newly generalizable information about potential cause-and-effect relationships and provides additional, more specific, information about the study participants. The citizen ID was matched with the Department of Health death certificate file in a manner that maintained the confidentiality of individual participant information (Muse, Mickl, Smith, 1995; Neutel, Johansen, Walop, 1991). All protocols were approved by the Institutional Review Boards at Princeton University, Georgetown University, and the Bureau of Health Promotion, Department of Health, Taiwan.

This sample comprised 4,440 survivors at the time of the 1999 survey, 1,864 of whom died by December 31, 2010 (see Figure 1 for a flowchart). On average, decedents were observed for 5.6 years (range 0.2–12.6) before their death, whereas those who survived to 2010 were followed for 11.8 years (range 2.5–13.0). Participants who were lost to follow-up (LFU) during the observation period included people who were alive but not interviewed and those who had emigrated before December 31, 2010. Of the eligible sample for this study, 238 had no valid data in 1999, 2003, and 2007 and were therefore excluded from our analysis. There were 2,471 individuals with complete data. The remaining 1,731 respondents had valid information for at least one wave but were LFU for one or two waves; these individuals did not contribute data for periods during which they were LFU. For example, if a participant was interviewed in 1999, LFU in 2003, interviewed in 2007, and was alive at the end of 2010, that person would have contributed data for 1999–2003 and 2007–2010 (but not 2003–2007). Those with unknown vital status or who emigrated were treated as censored at the date of their last interview.

We compared the sociodemographic characteristics of respondents who were LFU for one or more waves with individuals who had complete data ($n=2,471$). Those with no valid data at any of the three waves ($n=238$) and those who were LFU for one or two waves ($n=1,731$) were significantly ($p<0.001$ from t-tests) older at baseline and had fewer years of education than individuals with complete data.

To examine cause-specific mortality, we used cause of death (COD) categories that were based primarily on the International Classification of Disease (ICD)-9 codes. Among the 1,864 individuals who died during our study period (1999–2010), we have COD information for 1,844 individuals (20 [about 1%] were missing). For the 317 individuals with ICD-9 codes missing, 297 individuals had values for ICD-10 codes, which were used to determine COD. The ICD-10 codes were grouped with the appropriate ICD-9 coding categories based on the ICD-10/ICD-9 Comparability Ratio Table from the National Center for Health Statistics (Wisconsin Department of Health Services, 2013). Although we did not have the power to investigate the relationship between perceived stress and most cause-specific deaths (e.g., <5% of deaths were from external causes, with only 14 suicides), we were able to investigate the links between cardiovascular-related deaths ($n=458$; ICD-9 codes 280–289, 390–459 and ICD-10 codes D50–D89.9, I00–99.9) and perceived stress.

Measures

Perceived stress—Perceived stress was based on participant self-report (in 1999, 2003, and 2007) of whether each of six situations “makes you feel pressure or anxiety” (coded 0=none, 1=some, 2=or a lot; (Goldman et al., 2005)). These situations included: (1) the individual's own health; (2) own financial situation, (3) own job; (4) relationship with family members; (5) a family member's health, financial situation, job, or marriage; and (6) any other situation. The perceived stress index was created by summing the 6 items. The index ranged from 0 to 12, with higher scores indicating greater perceived stress. Respondents who were missing values for more than two domains were excluded from the analyses (6.9% of the sample at each wave).¹ For individuals with missing values on one or two domains, the perceived stress index was calculated from the available domains.² The six items loaded highly on one factor (eigenvalues were 1.64 in 1999, 1.49 in 2003, and 1.45 in 2007). Cronbach's alpha for the three waves were 0.68 in 1999, 0.65 in 2003, and 0.64 in 2007. We also examined a perceived stress index measure that excluded the individual's own health (range 0–10). To aid in interpreting the magnitude of the coefficients, perceived stress was standardized (M=0, SD=1) in the models. We consider 1999, 2003, and 2007 because the perceived stress questions were asked in the same manner for these study dates.

Control variables—We controlled for sociodemographic and health characteristics that have been related to both perceived stress and mortality. These variables included sex, educational attainment in years, age, marital status, chronic conditions, mobility limitations, depressive symptoms, emotional support, smoking status, and alcohol consumption. Participants were classified as married if they reported having a spouse or currently having a live-in companion. We controlled for health because poor health may be either a cause or a consequence of perceived stress.

We included a summary count measure for seven medical conditions (hypertension, diabetes, heart disease, stroke, kidney disease, liver disease, cancer) – all of which are among the top 10 leading causes of death in Taiwan (Department of Health 2011). Mobility limitations were defined as the number of mobility activities the participant reported any difficulty completing (range 0–8; Collins, Goldman, Rodríguez 2008). These activities included squatting, standing for 15 mins, grasping with fingers, reaching over one's head, walking 200–300 m, running 20–30 m, climbing 2–3 flights of stairs, and lifting/carrying 11–12 kg (Nagi 1969, 1976). The presence of medical conditions and reports of mobility limitations have been associated with mortality in older adult populations (e.g., Weiner et al. 2004; Melzer et al. 2003).

High levels of depressive symptoms have been reported as a risk factor for mortality in older adults (Schulz et al. 2000; Wulsin et al. 1999). Depressive symptoms were measured using a subset of 10 items from the 20-item Center for Epidemiological Studies Depression Scale

¹(1) In 1999: 16 individuals were missing 1 domain, 1 individual was missing 3 domains, and 307 were missing all 6 domains; (2) In 2003: 3 individuals were missing 1 domain, 1 individual was missing 3 domains, and 280 individuals were missing all 6 domains; and (3) In 2007: 1 participant was missing 1 domain, 1 participant was missing 4 domains, and 294 participants were missing all 6 domains.

²In calculating the full perceived stress index (range: 0–12) for individuals missing 1 or 2 domains, the following equation was used: [sum of scores (0, 1, or 2) for available perceived stress domains / (6 - #missing domains)]*6].

(CES-D; Radloff 1977). Reliability has been reported for abbreviated versions of the CES-D in Western (Andresen et al. 1994; Kohout et al. 1993) and Chinese populations (Krause and Liang 1992; Ofstedal et al. 1999), including populations in Hong Kong (Boey, 1999) and Taiwan (Chiao et al., 2009; Lee et al., 2009). Participants reported how often they experienced a number of different situations or feelings in the past week (0=not at all, 1=rarely or one day, 2=sometimes or two to three days, and 3=often/chronically or four or more days). The questions asked about poor appetite, poor sleep, exhaustion, being in a bad mood, unfriendliness of others, loneliness, inability to get going, anguish, feeling joyful, and feeling that life was going well. Positive items were reverse-scored and a summary measure was created (range 0–30), with higher scores reflecting more frequent depressive symptoms (Collins et al. 2009).

Given the protective effect of social support on mortality (Holt-Lundstad et al. 2010), we included emotional support in our models. Emotional support was represented by an index score created by summing responses to four items (range 0–20), with higher scores reflecting lower emotional support (Glei et al. 2012). In four questions, the participants were asked to what extent they felt that family, relatives or friends: were willing to listen when they needed to talk, made them feel loved and cared for, were satisfactorily providing them with emotional support, and could be counted on to take care of them when ill (1=a great deal, 2=quite a bit, 3=some, 4=very little, 5=not at all). We also included current smoking status and whether or not participants drank alcohol (0=no, 1=yes) because these behaviors have been associated with mortality (LaCroix et al. 1991; Shaper 1990).

Data Analysis

Hazard models were estimated to examine the relationship between perceived stress and age-specific mortality. In the analytic models shown here, perceived stress was treated as a time-varying measure. (In separate models described in the discussion section, a measure of chronic perceived stress was considered fixed.) Controls included fixed variables (sex and educational attainment) and time-varying covariates (marital status, self-rated health, chronic conditions, mobility limitations, depressive symptoms, emotional support, smoking status, and alcohol consumption). For all time-varying covariates, the values in a given wave (1999, 2003, and 2007) were used to predict mortality between that wave and the following wave.

We used a proportional hazards model to assess the association between perceived stress and age-specific mortality (1999–2010), using age as the primary clock. We did not find evidence for nonproportional hazards (i.e., the slope of mortality did not differ significantly by our covariates). The underlying hazard function was modeled with a Gompertz distribution, which was a good fit to our data and is often used to describe death rates at older ages (Horiuchi and Coale 1982). Model I adjusted for sex, education, marital status, and survey wave. In Model II, health indicators were added: number of medical conditions, mobility limitations, and depressive symptoms. To consider potential coping indicators, Model III adjusted for emotional support and behavioral factors (current smoking and alcohol consumption status) in addition to the covariates included in Model II. Given prior studies suggesting that the relationship between perceived stress and mortality differed by

sex (Iso et al. 2002), we also tested an interaction between sex and perceived stress. All analyses were conducted using STATA version 11 (StataCorp 2009).

RESULTS

Table 1 reports the sociodemographic characteristics and health status of the study population. There were slightly more men than women (50.7%), and the participants had an average of 5.0 years of total education. At baseline (1999), the average age was 68.6 years (range 50–95 years), 69% were married, the mean mobility limitation score was 2.2, 24% were current smokers, 24% were current alcohol consumers, and the mean perceived stress score was 1.8. By the end of 2010, 16% of the sample population had died. To identify factors thought to contribute to perceived stress, we examined the perceived stress score by sex and marital status (not shown). We found that men reported lower perceived stress than women at each of the three waves and married individuals reported lower perceived stress than non-married individuals in the 1999 and 2003 waves only.

The hazard ratios (HR) relating fixed and time-varying covariates, including perceived stress, to mortality during the 11-year follow-up period are shown in Table 2. The first model includes the fixed baseline variables and the time-varying covariates, survey wave and marital status. Higher perceived stress was associated with greater mortality such that a one standard deviation increase in perceived stress was associated with a 19% increase in mortality risk (HR=1.19; 95% CI 1.13–1.26; Model I). In Model II, the presence of additional medical conditions, mobility limitations and depressive symptoms was associated with higher mortality, but perceived stress was no longer associated with mortality. These relationships did not change in the full model (Model III). Models that tested for a sex interaction with perceived stress showed no evidence that the effect of perceived stress differed significantly by sex (not shown). An alternate operationalization of the perceived stress index that excluded an individual's own health resulted in a 45% reduction in the size of the coefficient for perceived stress in Model I (HR=1.10; 95% CI 1.04–1.17; results not shown). We also examined the causal effect of perceived stress on mortality after excluding deaths during the first five years of the study period; the fully adjusted model indicated no association between perceived stress and mortality (see Supplementary Table 1).

When considering cardiovascular and cancer-related mortality, perceived stress was not significantly associated with cardiovascular-related mortality in the fully adjusted model (similar to Model III, Table 2: HR=0.98, 95% CI 0.85–1.14 for cardiovascular mortality and HR=0.94, 95% CI 0.82–1.07 for cancer-related mortality; see Supplementary Tables 2 and 3, respectively).

DISCUSSION

Our study found that perceived stress predicted all-cause mortality in an older adult population in Taiwan. This relationship was, however, greatly attenuated when perceptions of stress regarding health were excluded, and it was not significant after adjusting for medical conditions, mobility limitations, and depressive symptoms. Prior studies of adult populations in South Korea (Khang and Kim 2005) and Denmark (Nielsen et al. 2008) found

that higher levels of perceived stress were associated with higher mortality, while a study in Scotland (Macleod et al. 2001) found no association. We extended this prior work by expanding the scope of perceived stress and by controlling for indicators of health, social support, and behavioral factors in our analysis. As in some prior studies, we found that after adjustment for sociodemographic factors alone, older adults with higher levels of perceived stress had a higher risk of dying within the follow-up period.

We suggest that there are two ways of explaining these findings. The results are consistent with a model in which health mediates the effects of perceived stress on mortality. In other words, higher perceived stress results in poorer health, which in turn, leads to a higher risk of dying. Thus, once current health is included in the model, perceived stress does not significantly affect mortality. Alternatively, one could argue that poor health affects both perceptions of stress and the risk of dying. If this were true, it would support the explanation that the relationship between perceived stress and mortality is spurious.

In support of the first explanation are findings from studies on the influence of stress (perceived stress and stress exposures) on cardiovascular, immune, and endocrine function (Adler et al. 2001; Black 2003; Cohen et al. 1991). Goldman et al. (2005) observed a positive association between perceived stress and indicators of physiological dysregulation, including elevated levels of cortisol and triglycerides and low levels of dehydroepiandrosterone sulphate (DHEAS), fasting glucose, and inflammatory marker interleukin-6. Extreme levels of many of these biological measures have been associated with poor health outcomes (Alley et al. 2007; Barrett-Connor et al. 1986; Gleib et al. 2004; Reuben et al. 2002; Roth et al. 2002), including mortality.

The alternate explanation focuses on the reverse causal process: high levels of perceived stress may be a result of the presence, development, or progression of health conditions. This explanation is supported by our finding that, in comparison with a measure that included stress related to the respondent's own health, the strength of the relationship between mortality and the measure of perceived stress that excluded the respondent's own health was greatly attenuated. Our data do not allow us to distinguish between these two causal explanations. We speculate that the dominant effect is that of reverse causality: concerns about health greatly contributed to the effect of perceived stress on mortality, and of course, diminished health predicts mortality.

To further test the relationship between perceived stress and mortality, we investigated the association between chronic perceived stress and mortality. Studies have demonstrated that persistent stress is linked to numerous poor health outcomes, including: vulnerability to the intensity and extent of the inflammatory cascade and healing conditions; reactivation of latent viruses (e.g., Epstein Barr virus and herpes simplex); and vulnerability to infections, HIV, cancer, and cardiovascular disease (Andersen, Kiecolt-Glaser, and Glaser 1994; Baum 1990; Cohen et al. 1998; Cohen, Tyrrell, and Smith 1991; Cohen and Williamson 1991; Glaser et al. 1994; Kiecolt-Glaser et al. 1998; Marucha, Kiecolt-Glaser, and Favagehi 1998; McKinnon W et al. 1989; O'Leary 1990). To test the association between chronic perceived stress and mortality, we created a dichotomous variable that identified individuals who reported moderate or high levels of stress at each of three waves (1999, 2003 and 2007) and

used this variable, along with the sets of control variables shown in Table 2, to predict mortality in the period 2007–2010. Our results mirror those based on the time-varying perceived stress index in Table 2, although the hazard ratio is larger: relative to individuals without chronic perceived stress, those with chronic perceived stress had an increased risk of mortality in Model I (HR 1.40, 95% CI 1.09–1.79); however, after adjusting for health conditions and behaviors (as in Models II and III), this relationship was no longer significant.

Our study has a number of strengths. This population-based survey of older Taiwanese adults included questions about perceived stress that were asked consistently at three times over an 8-year period. Multiple observations are important because variations in exposure to stress, which may underlie variations in perceived stress, have been associated with long-term alterations in the emotional, behavioral, and physiological responses that influence susceptibility to poor health outcomes (Cohen et al. 1997; McEwen et al. 1998). Consideration of perceived stress as a time-varying covariate also allows us to maximize the use of the data that are available. To our knowledge, only one other study (Macleod et al. 2001) has considered perceived stress at more than one time. Our six-item summary measure of perceived stress enabled us to consider an index of stress from multiple domains; previous studies examining the relationship between perceived stress and mortality have used a single question (Iso et al. 2002; Khang and Kim 2005) or four questions (Macleod et al. 2001) to assess stress. Lastly, the inclusion of multiple controls (fixed and time-varying) that comprised sociodemographic variables, indicators of health, social support and behavioral factors permitted us to consider a wide range of potential confounders and to examine the impact of reverse causality on the estimates.

We also note limitations of our study. One limitation is our 11-year follow-up period. Other studies that have examined the relationship between perceived stress and mortality include over 20 years of follow up (e.g., Macleod et al. 2001; Nielsen et al. 2008), but only one study (Macleod et al. 2001) examined perceived stress at more than one time. Under-reporting of perceived stress or variations (e.g., by sex or socioeconomic status) in thresholds for reporting perceived stress may attenuate or potentially bias the observed relationship between perceived stress and mortality. .

In conclusion, we find that the association between perceived stress and mortality is largely explained by an individual's current health. Whether the causal arrow underlying this association flows from perceived stress to health to mortality or from the effects of health on both perceived stress and mortality remains unresolved. Further studies could help determine whether there is a true effect of perceived stress (i.e., health as a mediator) or whether the association is spurious in two ways: by starting at younger ages (before the subjects have succumbed to various health problems) or by having frequent follow-ups (that allow one to precisely measure the timing of health problems relative to elevations in perceived stress). Such studies will require careful temporal ordering of events to establish the causal direction and will be critical to understanding the complex relationship between perceptions of stress and adverse health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Taiwan Longitudinal Study of Aging (TLSA), 1989–2007

Table 1

Sociodemographic characteristics and health status of the study population

	1999	2003	2007
	n=4132	n=3255	n=2915
Fixed baseline characteristics			
Male (%)	50.7		
Education (yrs)	5.0 (4.5)		
Time varying covariates			
Age (years)	68.6 (9.2)	72.3 (8.6)	74.4 (8.2)
Married (%)	69.2	72.0	69.0
Medical conditions (0–7) ^a	0.9(1.1)	0.9(1.1)	1.1(1.1)
Mobility limitations (0–8)	2.2 (2.5)	2.0 (2.4)	2.1 (2.5)
Depressive symptoms (0–30)	5.4(6.1)	4.8 (5.6)	4.8 (5.7)
Emotional support (0–25)	7.3 (2.9)	7.6 (2.9)	7.4 (2.7)
Currently smoking (%)	24.1	19.1	15.4
Currently consuming alcohol (%)	24.2	23.7	23.9
Perceived stress			
Mean (SD):			
Full index (0–12) ^b	1.8(2.1)	1.7(2.0)	1.6(1.9)
Index excluding own health (0–10)	1.3(1.7)	1.2(1.6)	1.1(1.5)
Died by end 2010 (%)		16.0	

Means (SD) presented, unless stated otherwise

^a Medical conditions included hypertension, diabetes, cardiovascular disease, stroke, cancer, liver disease, kidney disease^b Perceived stress – Full Index included reported stress on any of 6 perceived stress domains pertaining to the respondent's: own health; own financial situation; own job; family member's health, financial situation, job, marriage, etc.; relationship with family members; and any other domain

Table 2

Hazard ratios from Gompertz models predicting age-specific mortality (between 1999 and the end of 2010) from perceived stress as a time varying measure

Predictor	Model I		Model II		Model III	
	HR	95% CI	HR	95% CI	HR	95% CI
Fixed baseline characteristics						
Male	1.92*	1.68–2.21	2.49*	2.17–2.86	2.38*	2.04–2.76
Education	0.97*	0.96–0.98	0.98	0.97–1.00	0.98	0.97–1.00
Time varying covariates						
Control variables						
Survey wave	0.98*	0.96–0.99	0.97*	0.95–0.99	0.97*	0.95–0.99
Married	1.02	0.98–1.05	1.01	0.98–1.05	1.01	0.98–1.05
Medical conditions			1.13*	1.08–1.19	1.13*	1.08–1.19
Mobility limitations			1.22*	1.19–1.26	1.21*	1.18–1.25
Depressive symptoms			1.02*	1.01–1.04	1.02*	1.01–1.03
Emotional support					1.01	0.99–1.03
Currently smoking					1.28*	1.10–1.49
Currently consuming alcohol					0.77*	0.66–0.91
Perceived stress ^a	1.19*	1.13–1.26	0.94	0.87–1.01	0.94	0.87–1.01
Gamma for age (time clock)	0.09*	0.09–0.10	0.07*	0.06–0.08	0.07*	0.06–0.08

HR=Hazard ratio; CI= Confidence interval

* p<0.05

^a Standardized (M=0, SD=1)