HHS Public Access

Author manuscript

*Psychol Sci*. Author manuscript; available in PMC 2016 July 01.

Published in final edited form as:

*Psychol Sci*. 2015 July ; 26(7): 1063–1070. doi:10.1177/0956797615581491.

# Variability modifies life satisfaction's association with mortality risk in older adults

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## Abstract

Life satisfaction is associated with greater longevity, but its variability across time has not been examined relative to longevity. We investigated whether mean levels of life satisfaction across time, variability in life satisfaction across time, and their interaction were associated with mortality over 9 years of follow-up. Participants were 4,458 Australians initially ≥50 years old. During the follow-up, 546 people died. Adjusting for age, greater mean life satisfaction was associated with reduced risk and greater variability in life satisfaction was associated with increased risk of mortality. These findings were qualified by a significant interaction such that individuals with low mean satisfaction and high variability in satisfaction had the greatest risk of mortality over the follow-up period. In combination with mean levels of life satisfaction, variability in life satisfaction is relevant for mortality risk among older adults. Considering intraindividual variability provides additional insight into associations between psychological characteristics and health.

### Keywords

Life satisfaction; well-being; mortality; longevity; intraindividual variability; within-person stability

Life satisfaction is associated with beneficial health outcomes, including increased longevity (e.g., Bowling & Grundy, 2009; Collins, Glei, & Goldman, 2009; Koivumaa-Honkanen et al., 2000; Wiest, Schuz, Webster, & Wurm, 2011). For example, in men and women initially ages 25-74, those with higher life satisfaction levels had more than a 30% reduced risk of mortality during 12 years of follow-up, even controlling for health behaviors and body mass

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Author Contributions

The authors conceived of the research idea together. AW conducted statistical analyses with help from the other authors. JB wrote the first draft of the manuscript and revised subsequent drafts. AW, SS, and LK provided substantial comments on the manuscript and helped frame the paper. JB and AW had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final version of the manuscript for submission.

The authors have no conflicts of interest to report.

index (Lacruz, Emeny, Baumert, & Ladwig, 2011). However, most of these studies have used a single measure of life satisfaction to predict mortality risk (cf. Collins et al., 2009). Assessing life satisfaction at a single point in the life course cannot accommodate the growing recognition that individual differences exist in the extent to which psychological characteristics remain stable or are variable over time (Mroczek, Almeida, Spiro, & Pafford, 2006). Although life satisfaction is typically thought of as being relatively consistent across time, it may change in response to life circumstances with some individuals adapting more readily to new situations and others showing more long-lasting change (Fujita & Diener, 2005; Lucas & Donnellan, 2007). This is especially true in the context of major life events such as unemployment or divorce (Luhmann, Hofmann, Eid, & Lucas, 2012).

Given that life satisfaction may vary across time, we investigated whether intraindividual variability in life satisfaction might be related to risk of mortality over the nine-year follow-up period. Past work suggests that variability in psychological characteristics may be as important as mean levels, particularly with regard to mortality risk (Eizenman, Nesselroade, Featherman, & Rowe, 1997; Mroczek et al., 2013). Moreover, greater variability in life satisfaction is correlated with meaningful outcomes such as less personal control, less social support, greater daily hassles, and worse physical health (Gadermann & Zumbo, 2007).

Thus, we had three goals in this research. First, to expand beyond the well-established finding that higher levels of life satisfaction at a single point in time are related to reduced mortality risk, we investigated whether higher levels of *mean* life satisfaction derived from repeated assessment across nine years would be associated with reduced mortality risk. Second, we investigated whether variability in levels of life satisfaction over time would be associated with mortality risk. We hypothesized that individuals with greater variability in life satisfaction would have increased risk of mortality during the follow-up period. Third, and perhaps most critically, we examined whether variability in life satisfaction would modify the relationship between mean life satisfaction and mortality risk (or whether mean life satisfaction would modify the relationship between variability in life satisfaction and mortality risk). Following prior work in this area, we considered relevant covariates that might confound the association (i.e., sociodemographic factors, health conditions) or be on the pathway linking life satisfaction to mortality (i.e., health behaviors; Chida & Steptoe, 2008).

## Methods

### Sample

Participants were from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Survey was established in 2001 (Wave 1) to investigate social and economic issues in a national probability sample of Australian households. At the first assessment, there were 19,914 individuals from 7,682 households. Interviews have been conducted annually with adult participants. The current research follows participants through 2010 (Wave 9), which was the last available year when this research project started. From the original sample of 19,914, we excluded individuals younger than 50 years old ($N$ = 14,789) because most (91%) adult deaths occurred in older individuals. We also excluded adults 50 years and older with fewer than two assessments of life satisfaction ($N$ = 667).

Thus, the present research was based on participants who were 50 years or older at Wave 1 and had complete data on life satisfaction and date of death ($N$ = 4,458). When comparing the analytic sample to individuals over 50 years old with fewer than two assessments of life satisfaction, the latter tended to be male, less educated, physically inactive, and more likely to die during the follow-up period.

Of the 4,458 eligible participants, 2,347 (52.65%) were women. The average baseline age of participants was 63.32 years ($SD$ = 9.83; minimum = 50; maximum = 92) and 13.23% had a bachelor's degree or higher level of education. Participants were generally healthy: 61.75% were free from long-term health conditions, 49.81% had never smoked cigarettes, and 48.56% engaged in physical activity at least three times per week.

All participants provided informed consent and relevant Institutional Review Boards approved the research.

## Measurement

**Life satisfaction—**Participants reported their life satisfaction at least twice and up to nine times using a commonly-used single item measure of life satisfaction: "All things considered, how satisfied are you with your life?" (Bjørnskov, 2010). Responses ranged from 0 to 10 (higher numbers indicated more life satisfaction). Most participants (62%) reported life satisfaction at all nine waves. For each participant, mean levels of life satisfaction across time and the standard deviation of life satisfaction across time were calculated using all available scores. The standard deviation can serve as a reliable and straightforward indicator of the amount of spread within a set of scores (Eid & Diener, 1999). The overall sample mean of mean life satisfaction was 8.17 ($SD$ = 1.23; minimum = 0.33; maximum = 10.00). The overall sample mean of the standard deviation of life satisfaction was 0.95 ($SD$ = 0.63; minimum = 0.00; maximum = 5.29). Individual means and standard deviations were moderately correlated, $r = -.44$, $p < .0001$. Both the mean and standard deviation of life satisfaction were standardized ($M$ = 0, $SD$ = 1) prior to inclusion in the statistical models.

**Covariates—**Sociodemographic covariates included age, gender (women [reference], men), and education (less than a high school degree [reference], high school degree or equivalent, some college or vocational training, bachelor's degree or more). Health-related covariates included long-term health conditions, disabilities, or impairments (none [reference], one or more), cigarette smoking status (never smoker [reference], former smoker, current smoker), and physical activity (not at all [reference], moderate: ≤1 to 2 times per week, high: ≥3 times per week).

Given that depression is associated with increased risk of mortality (Schulz et al., 2000; Wulsin, Vaillant, & Wells, 1999), we controlled for depressive symptoms to ensure that life satisfaction was not simply a marker of the absence of depression. Depressive symptoms were assessed with the 5-item Mental Health subscale of the Short Form-36 (Ware & Sherbourne, 1992). Higher scores indicated more depressive symptoms. The internal consistency reliability of the 5 items was good ($\alpha$ = 0.81; $M$ = 75.75; $SD$ = 17.33; minimum = 0; maximum = 100). Because of life satisfaction's potential overlap with positively-

worded items on the Short Form-36, a 3-item composite excluding the two positively-worded items was also explored; analyses with this scale yielded nearly identical findings to those presented and are not discussed further.

All categorical covariates were dummy coded prior to inclusion in the analysis. All covariates were self-reported at Wave 1.

**Mortality—**Date of death (month/year) was assessed by interviews with surviving members of the household or other contacts. In cases where the respondent was known to be deceased but date of death was unknown, the period of death was approximated by fieldwork period (e.g., death between Waves 4 and 5). We retained only the year of death (not month) and coded deaths between Waves 1 and 2 as year 2002, between Waves 2 and 3 as year 2003, etc.

## Statistical Analyses

SAS 9.3 was used for all statistical analyses. Preliminary analyses investigated associations between mean levels of life satisfaction or the standard deviation of life satisfaction with covariates using correlations, *t*-tests, and ANOVAs. In addition, the number of people with high (top 25%), moderate (middle 50%), and low (bottom 25%) mean levels of life satisfaction were crossed with the number of people with high, moderate, and low variability in life satisfaction to determine frequencies.

Cox proportional hazards regression models estimated hazard ratios (HRs) and 95% confidence intervals (CIs). Missing values on covariates were imputed through multiple imputation procedures and estimates were pooled from five imputed datasets. As a descriptive step, mortality risk was initially separately investigated in relation to mean life satisfaction across time and the standard deviation of life satisfaction across time prior to more complex models that included the interaction. Such models also allowed us to replicate the well-established association between higher levels of life satisfaction and reduced risk of mortality, and provide information for future researchers seeking to synthesize the literature. The primary Cox proportional hazards regression model included the interaction between mean life satisfaction and variability in life satisfaction across time, as well as the lower order effects. Each Cox proportional hazards regression model first adjusted for age (Model 1) and then additionally adjusted for sociodemographic covariates (age, gender, education) and health conditions (Model 2). A third model additionally included health behaviors that could be on the pathway linking life satisfaction with mortality (smoking status, physical activity; Model 3) and a fourth model included depressive symptoms (Model 4).

The assumption of proportional hazards was tested in an extended Cox model that included time-dependent variables (Kleinbaum & Klein, 2010). The time-dependent variable for age was statistically significant, so we reran all primary models including time-dependent age. Results from models including time-dependent age were practically identical to those presented (Table S1 in the Supplemental Material online shows a comparison of the findings).

Sensitivity analyses investigated how clustering by household, personality traits, and terminal decline impacted the primary findings. In analyses that accounted for clustering by household, HRs remained unchanged and conclusions about statistical significance were identical. Given that findings were similar to the primary results, we do not discuss them further. In addition, because certain personality traits are related to mortality risk (Wilson, de Leon, Bienias, Evans, & Bennett, 2004), in our most fully-adjusted model we controlled for the Big Five personality traits, which were first assessed in Wave 5 of HILDA (Watson & Wooden, 2010). Using five different approaches, we also investigated the issue of terminal decline whereby life satisfaction decreases rapidly close to death (Gerstorf, Ram, Estabrook, et al., 2008). To this end, we first used multilevel models to determine whether there was evidence of terminal decline in our sample. Second, among those people who died, we evaluated the magnitude of the terminal decline effect by centering time around the year of death rather than study baseline. This approach allowed us to see changes in life satisfaction as death approached. Third, we examined how terminal decline contributed to our results by calculating the detrended residual in life satisfaction after effects due to total and individual change over time (the latter of which included effects of terminal decline) were removed. Fourth, we tested whether variability in the detrended residual in life satisfaction would predict mortality risk in the Cox proportional hazards regression models. Finally, in a fifth approach we examined whether level of life satisfaction assessed at the first wave (and therefore the least likely to be subject to terminal decline as it was the furthest available point from death) was associated with mortality risk. The Supplemental Material online presents the terminal decline findings in detail.

## Results

### Preliminary analyses

Higher mean life satisfaction was significantly associated with older age, earning less than a high school degree, fewer health conditions, not smoking, and more physical activity ($p < .05$); however, there was no association with gender ($p > .05$). Greater variability in life satisfaction was significantly associated with older age, being female, earning less than a high school degree, having more health conditions, smoking, and less physical activity ($p < .05$). The number of people with low, moderate, and high levels of mean life satisfaction crossed with low, moderate, and high variability in life satisfaction is shown in Table 1.

### Life satisfaction and mortality risk

During the 9-year follow-up, 546 (12%) of the participants died. After adjusting for age at baseline, each standard deviation increase in mean level of life satisfaction (i.e., a difference in the individual mean of 1.23 scale points) was significantly associated with 18% reduced risk of mortality. This relationship persisted when additionally controlling for gender, education, and health conditions, but was attenuated and became only marginally significant when health behaviors were added. When depressive symptoms were further included, the association remained unchanged but non-significant. See Table 2, models 1-4. Notably, depressive symptoms were not significantly associated with mortality risk in the fully-adjusted model (HR = 1.00, 95% CI [0.99, 1.01]).

When the standard deviation of life satisfaction was included in a separate model adjusting for age, each standard deviation increase in the variability of life satisfaction (i.e., a difference in the individual standard deviation of 0.63 points) was significantly associated with 20% increased mortality risk. The association was unchanged when additionally controlling for gender, education, and health conditions, but became only marginally significant when including health behaviors. Adding depressive symptoms to the model did not alter these findings. See Table 2, models 1-4.

The initial findings regarding mean levels of life satisfaction and variability in life satisfaction were qualified by a significant interaction effect, controlling for age and the lower order effects (HR = 0.92; 95% CI [0.87, 0.97]). Figure 1 shows the predicted slopes for high, typical, and low mean levels of life satisfaction at high (+1 SD), sample mean, and low (−1 SD) variability levels, controlling for age. Simple main effect analyses showed that the risk of mortality over the follow-up period was significantly associated with variability at low mean levels of life satisfaction (HR = 1.13; 95% CI [1.03, 1.24]), but not with typical (HR = 1.04; 95% CI [0.94, 1.16]) or high levels (HR = 0.96; 95% CI [0.84, 1.10]). Individuals with the highest mortality risk had low mean life satisfaction and the greatest variability in life satisfaction. In contrast, individuals with high mean life satisfaction tended to have reduced risk for mortality, regardless of the variability in their life satisfaction levels. The interaction between mean levels of life satisfaction and variability in life satisfaction remained statistically significant – with the magnitude of effect relatively unchanged – after additionally controlling for gender, education, health conditions, health behaviors, and depressive symptoms (Table 2, Models 2-4). In addition, Figure S1 in the Supplemental Material online shows the survival curves for the four most extreme groups: high mean/high standard deviation; high mean/low standard deviation; low mean/high standard deviation; low mean/low standard deviation.

When the Big Five personality traits were added to the fully-adjusted model with the interaction between mean life satisfaction and variability in life satisfaction (and their lower-order effects), results remained mostly the same ($HR_{\text{without personality}}$ = 0.91, 95% CI [0.86, 0.96] versus $HR_{\text{with personality}}$ = 0.90, 95% CI [0.85, 0.95]). Extraversion was the only personality trait to show a significant association with mortality risk (HR = 0.88, 95% CI [0.80, 0.96]).

Finally, additional analyses (presented in the Supplemental Material online) tested the presence of terminal decline. Terminal decline was observed; however, using variability in the detrended residual (i.e., net variability with the variance attributable to terminal decline removed) was highly correlated with the variability in the raw score of life satisfaction and, when substituted for raw score variability among those who died, replicated the primary findings regarding mortality risk. Furthermore, substituting baseline life satisfaction (the furthest point from death) for mean life satisfaction replicated findings with regard to mortality risk, further ensuring that associations were not due to reverse causality.

## Discussion

This is the first study to consider effects of life satisfaction on risk of mortality when life satisfaction is summarized across as many as nine repeated assessments. One other study has repeatedly assessed life satisfaction in the context of mortality, but only three repeated assessments were available (Collins et al., 2009). We initially found that higher mean life satisfaction across nine years was associated with reduced risk of mortality over the follow-up period. Moreover, greater variability in life satisfaction across nine years was associated with an increased risk of mortality. The more dramatic the lability in life satisfaction across time, the greater one's mortality risk. No other study has investigated how variability in life satisfaction is related to longevity. Although some variability in psychological well-being may have beneficial effects in that it signals an individual's ability to adapt (Gruber, Kogan, Quoidbach, & Mauss, 2013; Röcke & Brose, 2013), our initial findings suggest that high levels of variability (perhaps more indicative of instability) are detrimental to longevity.

However, these initial findings are qualified by an interaction such that the effects of mean life satisfaction on mortality risk depend on variability in those levels or vice versa (i.e., the effects of variability in life satisfaction on mortality risk depend on mean life satisfaction). This is consistent with previous findings regarding associations between variability in psychological functioning and mortality (Mroczek et al., 2013). Specifically, we found that individuals with relatively low mean life satisfaction that also varied greatly across time tended to have the highest mortality risk during the follow-up period. In comparison, individuals with relatively high mean life satisfaction had a reduced risk for mortality, regardless of how life satisfaction varied over time (i.e., the effect of variability only seemed to matter among individuals with relatively low mean levels of life satisfaction). The interaction between the mean and standard deviation of life satisfaction over time held after controlling for numerous covariates. Also worth noting is that individuals with low mean life satisfaction levels were also more likely to exhibit higher variability in those levels relative to those with higher mean life satisfaction levels.

No research to date has examined the interplay between mean life satisfaction and variability in life satisfaction over time in relation to an objective health outcome such as mortality. Investigators have speculated that variability can signal poor emotion regulation and an inability to adapt to the environment (Röcke & Brose, 2013). Our findings support this perspective, indicating not only that persistently low life satisfaction over time may reduce longevity, but also that high variability in those levels may be particularly detrimental when cycling in the lower ranges of life satisfaction. Such conditions might occur when individuals repeatedly encounter distressing events in their lives – for example, losing a job or the death of a loved one. Life circumstances that are continually in flux may prevent individuals from “getting used to” their conditions. In other words, the process of hedonic adaptation – whereby effects of unfavorable or favorable events on well-being diminish over time – does not have the chance to occur because the context is changing (Frederick & Loewenstein, 1999). Although variety in positive experiences may help prolong positive thoughts and feelings (Sheldon & Lyubomirsky, 2012), variety in negative experiences may be damaging because hedonic adaptation and coping processes are delayed or never have a chance to occur (Röcke & Brose, 2013).

As with any research investigation, the current study has limitations. Participants were Australians who were 50 years or older, so generalization to other cultural and age groups is not warranted. Only all-cause mortality was available, so we were unable to distinguish among causes of death. In addition, because few participants had very low levels of life satisfaction, a restricted range or a ceiling effect is possible (Diener & Diener, 1996). Another potential limitation is determining whether the variability in life satisfaction captured with the standard deviation was meaningful or due to measurement error within a single-item measure. However, split-half reliability suggested the standard deviation of life satisfaction was a stable individual difference ($r$ = .46). Future research could investigate other conceptualizations of intraindividual variability, especially with approaches that capture rate of change (Eid & Diener, 1999; Estabrook, Grimm, & Bowles, 2012). In addition, although we were able to control for the Big Five personality traits with no substantive change to the associations under investigation, the traits were assessed partway through the follow-up period. Future research that adjusts for baseline traits would be methodologically preferred. Another possible limitation is that a third variable may be operating. For example, negative life events or declining health may precede death and be associated with changes in life satisfaction. Although such speculations cannot be confirmed with HILDA data, further examination is warranted with additional life satisfaction assessments and explanatory variables.

These limitations are balanced by many strengths including prospective and repeated measurement of life satisfaction across nine years, limited attrition, validated measures of potential confounders and pathways, and careful attention to the issue of terminal decline (Gerstorf, Ram, Rocke, Lindenberger, & Smith, 2008). Although terminal decline was present among those individuals who died during follow-up, it is unlikely that reported associations are due to declining life satisfaction in the few years immediately preceding death.

This research adds to the relatively scarce body of work regarding intraindividual variability (Biesanz, West, & Kwok, 2003) and effects of long-term well-being on mortality risk. Findings broadly demonstrate not only that psychological attributes themselves may be critical correlates of health, but also that variability in psychological attributes over time may be meaningful, especially in combination with mean levels. This is consistent with research suggesting that variability in psychological characteristics by itself (or in combination with mean levels) is relevant for risk of mortality (Mroczek & Spiro, 2007), health behaviors (Ong et al., 2013), depression and anxiety (Gruber et al., 2013), and self-reported health (Turiano et al., 2012). Furthermore, extreme variability in psychological states is often associated with mental health disorders (e.g., bipolar depression). Thus, while some level of adaptability and range is likely important for healthy psychological functioning (Kashdan & Rottenberg, 2010), extreme cycling may be harmful in and of itself or may serve as a marker of dysregulation in emotional or behavioral domains that influence health.

Healthy People 2020 highlights the critical impact of mental health on physical health, with increasing research demonstrating that mental health problems are associated with the prevalence and progression of many chronic diseases including diabetes, heart disease, and

cancer (Office of Disease Prevention and Health Promotion, 2010). In contrast, positive mental health constructs such as life satisfaction appear to protect against disease (e.g., Boehm & Kubzansky, 2012). Thus, it may be beneficial for clinicians to consider the role of mental health more explicitly in relation to physical health. While clinicians often focus on symptoms of depression or anxiety, the current study suggests that it may also be important to investigate the development and maintenance of positive well-being such as life satisfaction. Moreover, clinicians may want to consider the role of variability in positive well-being in relation to physical health.

Limited research has investigated whether interventions with an emphasis on positive psychological functioning translate into health benefits (e.g., Huffman et al., 2011; Ogedegbe et al., 2012; Peterson et al., 2012), and no research has investigated whether interventions related to variability may have effects. However, findings reported here indicate not only that variability in life satisfaction plays a critical role in understanding associations with health and longevity, but also that a single cross-sectional snapshot of life satisfaction may not tell the whole story. In sum, when considering the potential impact of mental health on aging and longevity, it may be important to go beyond a focus on mental health problems to consider not only positive psychological functioning such as levels of life satisfaction, but also within-person stability over time and their interaction (Röcke & Brose, 2013).

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgements

Support for this research was provided by the Robert Wood Johnson Foundation through a grant, “Exploring the Concept of Positive Health,” to the Positive Psychology Center of the University of Pennsylvania, Martin Seligman, project director. Additional support was provided by the National Institute of Aging (K02-033629).

The Household, Income and Labour Dynamics in Australia Survey was initiated and is funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this paper are those of the authors and should not be attributed to either FaHCSIA or the Melbourne Institute.

The authors wish to thank Brent Roberts for insightful discussions about this topic. Findings reported here were previously presented at the 2014 annual meetings of the American Psychosomatic Society and the Gerontological Society of America.

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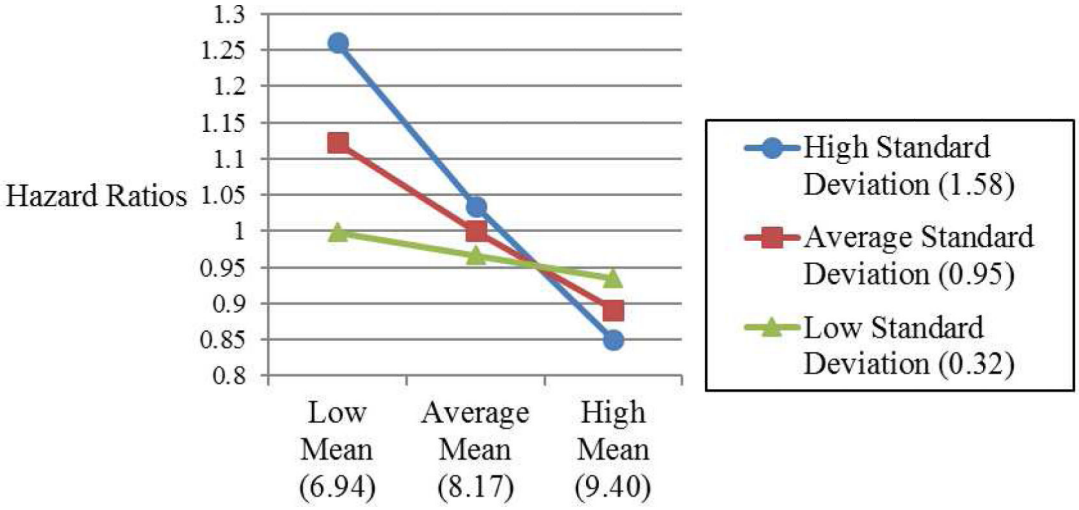


**Figure 1.**

Model results illustrating predicted mortality risk at different levels of mean life satisfaction over time and at different levels of variability in levels of life satisfaction over time (controlling for age).

## Table 1

Number of people across high, moderate, and low levels of mean life satisfaction and the standard deviation of life satisfaction ($N$ = 4,458)

| | | Variability in life satisfaction | | |
|---|---|---|---|---|
| | | **Low (bottom 25%)** | **Moderate (middle 50%)** | **High (top 25%)** |
| Mean levels of life satisfaction | Low (bottom 25%) | 84 | 462 | 610 |
| | Moderate (middle 50%) | 492 | 1,303 | 460 |
| | High (top 25%) | 413 | 602 | 32 |

## Table 2

Hazard ratios [95% confidence intervals] for the association between mortality risk over 9 years of follow-up and the mean level of life satisfaction over time, the standard deviation of life satisfaction over time, or their interaction[a]

| | Model | | | |
|---|---|---|---|---|
| | **Model 1[b]** | **Model 2[c]** | **Model 3[d]** | **Model 4[e]** |
| Mean of life satisfaction | 0.82**** [0.76, 0.89] | 0.87*** [0.80, 0.95] | 0.93† [0.86, 1.01] | 0.93 [0.84, 1.02] |
| Standard deviation of life satisfaction | 1.20**** [1.11, 1.29] | 1.15*** [1.06, 1.24] | 1.08† [1.00, 1.17] | 1.08† [0.99, 1.18] |
| Mean of life satisfaction * Standard deviation of life satisfaction[f] | 0.92** [0.87, 0.97] | 0.91*** [0.86, 0.96] | 0.91*** [0.86, 0.96] | 0.91*** [0.86, 0.96] |

[a] There were 4,458 participants and 546 cases in each model

[b] Adjusted for age

[c] Adjusted for demographic characteristics (age, gender, education) and health conditions

[d] Adjusted for demographic characteristics, health conditions, and health behaviors (smoking status, physical activity)

[e] Adjusted for demographic characteristics, health conditions, health behaviors, and depressive symptoms

[f] The models with the interaction term also controlled for the lower order effects (i.e., the mean of life satisfaction and the standard deviation of life satisfaction)

† $p \leq .10$

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

**** $p \leq .0001$