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Increases in Blood Glucose in Older Adults: The Effects of Spousal Health

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Abstract

Objectives—The death or illness of a spouse negatively affects a partner's health, but little is known about the effect on blood glucose (glycemic) levels. This study investigates the extent to which a spouse's declining health or death is associated with changes in the glycemic levels of older adults.

Methods—Data come from a nationally representative longitudinal sample of 597 Taiwanese (aged 54 to 90). We use changes in spousal health and death of a spouse to predict changes in glycosylated hemoglobin (HbA_{1c}) levels over a six-year period.

Results—A decline in spousal health is associated with increased HbA_{1c} levels for women, but not for men. The death of a healthy spouse is associated with increased HbA_{1c} levels for both genders.

Discussion—Stressful life transitions may compromise the glycemic levels of older adults. Taking on a caregiving role may erode some of the benefits of marriage and interfere with women's maintenance of their own health.

Keywords

Spousal health; Blood glucose; Gender; Taiwan

Introduction

Marriage benefits an individual's health in various ways, including promoting healthful behaviors (Umberson, Crosnoe, & Reczek, 2010), reducing the risk of acute and chronic illnesses (Gordon & Rosenthal, 1995), and increasing longevity (Goldman, Korenman, & Weinstein, 1995). However, at older ages many married individuals, especially women, experience the death of a spouse—one of the most stressful life transitions (Waite, 2009). Losing a spouse often leads to health declines (Das, 2013) and increased risk of mortality (Goldman et al., 1995), but having an ailing or disabled spouse—which can be a chronic

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stressor—also has substantial adverse health consequences (Schulz & Beach, 1999; Siegel, Bradley, Gallo, & Kasl, 2004). Spousal illness and death may be particularly challenging for older people, who may themselves be experiencing functional and cognitive declines (Mehta, Yaffe, & Covinsky, 2002).

The elevated risk of morbidity and mortality among older people whose spouse falls ill or dies may result from stress-induced physiological pathways. Several studies show that among older adults, spousal illness or death is associated with poor profiles of biomarkers of the cardiovascular system, metabolic processes, and immune function. For example, compared with older adults who have a healthy spouse, those who care for an ill spouse tend to have elevated blood pressure (Shaw et al., 1999), high triglycerides, low high-density lipoproteins (Vitaliano, Russo, & Niaura, 1995), and compromised immune response (Kiecolt-Glaser, Dura, Speicher, Trask, & Glaser, 1991). Similarly, losing a spouse is associated with high blood pressure and elevated heart rate (Das, 2013) and impaired immune function (Irwin et al., 1990). However, we are aware of only a few studies that have investigated the effect of a spouse's declining health or death on glycemic levels. The lack of such research is surprising because (1) Type 2 diabetes is common among people aged 65 and older, (2) glycemic control is vital to preventing or delaying the onset of diabetes and its complications, and (3) diabetes-related morbidity and mortality and related health care expenses burden individuals, health care systems, and society as a whole (Deshpande, Harris-Hayes, & Schootman, 2008; Fagot-Campagna, Bourdel-Marchasson, & Simon, 2005; Shaw, Sicree, & Zimmet, 2010).

No prior studies have identified a significant association between spousal health and elevated glycemic levels; however, the few studies that have explored this issue suffer from serious limitations. One study that compared a clinical sample of spousal caregivers of Alzheimer patients to a control group found that caregiving status is not significantly associated with elevated blood glucose levels (Vitaliano, Scanlan, Krenz, Schwartz, & Marcovina, 1996). However, this study did not use population-level data and focused on caregiving vs. non-caregiving. Another study—of older adults living with their spouse—found no significant difference in blood glucose levels among (1) those whose spouse was not disabled, (2) those who were not caregivers for a disabled spouse, (3) those who were caregivers, and (4) those who reported caregiving strain (Schulz et al., 1997). Though this study used population-level data and included more caregiving categories, the data were cross-sectional. In contrast, using data from a nationally representative probability sample, one study indicated that older widowed adults are more likely to have higher glucose levels than those who are cohabiting or married and that this association is statistically significant only for women (Das, 2013). This study focused on the effects of widowhood—comparing the widowed with all married adults regardless of their spouses' health. Such comparisons do not account for heterogeneity in glucose levels as a function of spousal health status. For example, given that marital dissolution may entail relief for those in a strained marriage (Umberson, Thomeer, & Williams, 2013), the loss of an ailing spouse may not substantially change glucose levels.

Despite the lack of evidence to date, there are several reasons to expect glycemic levels among older adults – especially long-term caregivers – to be associated with their spouse's

health. First, the cumulative physiological toll in response to excessive or persistent stress may increase glycemic levels (Geronimus, Hicken, Keene, & Bound, 2006; McEwen, 1998). The association between stress and glycemic control might result from a direct effect of stress hormones. During stressful situations, several hormones are released from stress response systems (e.g., the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis). Some stress hormones, such as norepinephrine, epinephrine, cortisol, β-endorphin, and growth hormone, can affect glucose homeostasis by interfering with various metabolic functions, such as insulin release, glucose utilization, and hepatic glucose production (Kyrou & Tsigos, 2009; Wing, Epstein, Blair, & Nowalk, 1985). Under stressful conditions, insulin sensitivity and the storage of glycogen (a mobilized storage form of glucose) in muscle decrease while hepatic glucose production increases. Chronic activation of stress systems, therefore, can render these metabolic activations detrimental by prolonging their duration, which may ultimately lead to elevated glycemic levels (Dungan, Braithwaite, & Preiser, 2009; Kyrou & Tsigos, 2009).

Second, during spousal illness or following the death of a spouse, individuals may lose some of the health-promoting benefits of marriage, including social attachment, emotional support, and financial resources (Ross, 1995; Waite, 2009), which help them to control their glycemic levels (Beverly, Miller, & Wray, 2008). Social control theory suggests that marriage benefits individuals' health through spousal management of health behaviors (Smith & Christakis, 2008; Umberson, 1992). Spousal illness or death might signal the loss of a lifelong partner who monitors an individual's health, reminding or pressuring them to adhere to health practices that control their glycemic levels. In addition, older adults who take care of their spouse may focus on their spouse's health at the expense of their own health, allocating insufficient time for rest, exercise, or routine medical care (Burton, Newsom, Schulz, Hirsch, & German, 1997). Having a spouse fall ill may be particularly challenging for individuals who must perform multiple self-management tasks daily to keep their glycemic levels under control, including physical activity, dietary adjustments, and regular monitoring of blood glucose (Bourdel-Marchasson et al., 2009). Long-term or intensive caregiving may make a partner feel isolated and depressed, which may result in poor glycemic control (Lustman et al., 2000).

Little is known about gender differences in the impact of a spouse's declining health on changes in glycemic levels. Although declining spousal health is a chronic stressor for both men and women, a stress process model suggests that the impacts depend on the socioeconomic position of those facing the stressor and on the coping resources they have at their disposal (Pearlin, Aneshensel, & LeBlanc, 1997; Thoits, 2010). In particular, for older women the economic security provided by marriage is critical for wellbeing. A husband's illness may result in reduced economic resources and increased financial hardship (Umberson, 1992), which might lead to psychological distress and elevated glucose levels. In addition, social norms and cultural expectations regarding caregiving may differentially influence men's and women's health if their spouse falls ill. The majority of (informal) caregivers are wives or daughters (Miller, 1990). Compared with male caregivers, female caregivers allocate more time to caregiving (Gallicchio, Siddiqi, Langenberg, & Baumgarten, 2002), receive less caregiving support (Sugiura, Ito, Kutsumi, & Mikami, 2009), and report higher levels of stress, emotional exhaustion, and physical symptoms

(Pinquart & Sörensen, 2006). Accordingly, compared to men, women may have more difficulty managing their glycemic levels when their spouse falls ill.

Using data from the 2000 and 2006 Social Environment and Biomarkers of Aging Study (SEBAS), a longitudinal national probability sample of middle-aged and older adults, this study is the first to examine (1) the extent to which a spouse's declining health or death is associated with a change in glycemic levels over a six-year period and (2) whether the associations vary by gender. Our study sheds light on how to improve social services and health-related interventions for older people who experience stressful life transitions.

Methods

Data

We use data from SEBAS, which is based on a random subsample of respondents from the Taiwan Longitudinal Study of Aging (TLSA). TLSA, which began in 1989 with follow-up interviews approximately every three years, is a national probability sample of persons aged 60 and older. In 2000, a sample of respondents interviewed in the 1999 TLSA was selected to participate in SEBAS. Of the 1,497 people who completed in-home interviews, 1,023 respondents completed a hospital-based physical examination (a weighted response rate of 70.5%). These individuals did not differ significantly from those who did not complete the examination in terms of gender, self-reported health status, or socioeconomic status (Goldman, Lin, Weinstein, & Lin, 2003). Of the survivors to the 2006 wave, 73 were lost to follow-up (a weighted attrition rate of 8.7%), 757 people completed in-home interviews, and 639 of those received an examination (a weighted response rate of 84.7%). Data quality evaluations show that missing responses are relatively rare for SEBAS and that reported information, such as job and marital history, has high consistency across the 2000 and 2006 waves (Chang et al. 2012).

The physical examination followed a similar protocol in both waves. Several weeks after the in-home interview, participants fasted overnight and provided a 12-hour overnight urine sample. The following morning, medical professionals collected blood samples and administered a medical examination at a nearby hospital. Completion rates for the protocol were high in both waves (≥ 88%) (Glei, Goldman, Lin, & Weinstein, 2011). Blood and urine specimens were analyzed at Union Clinical Laboratories in Taipei. The results of routine standardization and calibration tests indicated high intra-lab reliability for most biomarkers (e.g., glycosylated hemoglobin ≥ 0.96 in 2000 and ≥ 0.99 in 2006). Additional details about the study are provided elsewhere (Chang et al. 2012). All protocols were approved by the Institutional Review Boards at Princeton University, Georgetown University, and the Bureau of Health Promotion, Department of Health, Taiwan.

Of the 639 respondents who received a physical examination in both waves, the analyses presented here exclude 42 respondents who never married; were cohabiting, divorced or formally separated; were married but did not report their spouses' health; or for whom glycemic measurements were missing.

Measures

We use data from the 2000 and 2006 waves, designated T_1 and T_2 respectively, in the tables. In each wave, currently married respondents assessed their spouse's current health on a 5-point scale, ranging from very good to very poor. Respondents in the sample who were not currently married were widowed. A spouse's health status and death together define a predictor with six categories, which we present using two variables: (1) a linear score ranging from 0 for very good to 4 for very poor health (tests indicated that the linearity assumption was appropriate), and (2) a dummy variable for widowhood. We present two coefficients representing the effects of (1) spouse's deteriorating health and (2) becoming widowed compared with having a spouse in very good health. This choice of reference cell is convenient because it facilitates presentation in terms of deteriorating health and death, but is otherwise arbitrary and does not preclude calculating other comparisons of interest.

The SEBAS data include two glycemic biomarkers: fasting plasma glucose and glycosylated hemoglobin (HbA_{1c}), a measure expressed as a percentage of the amount of sugar bound to hemoglobin in red blood cells. An HbA_{1c} range of 5.7 to 6.4% is identified with pre-diabetes; anything greater (≥ 6.5%) is considered as a diagnostic criterion for diabetes (American Diabetes Association, 2006). We focus on HbA_{1c} because (1) HbA_{1c} captures chronic hyperglycemia better than fasting plasma glucose, (2) HbA_{1c} is less sensitive to non-compliance with fasting, and (3) HbA_{1c} has lower biological variability within an individual across assessments (Bonora & Tuomilehto, 2011). Consistent with prior studies (e.g., Das, 2013), we include HbA_{1c} as a continuous variable with higher levels of HbA_{1c} indicating poorer glycemic control. Nonetheless, we also estimate all models using fasting plasma glucose and report differences in results in the discussion. We include age, education (years of schooling), spousal health/death at T_1, and HbA_{1c} at T_1 as controls.

Statistical analyses

We consider two key statistical issues. First, changes in glycemic levels and spousal health and death between waves may be confounded by glycemic levels at T_1. For example, individuals who were aware of their high glycemic levels at T_1 may have expended greater effort at glycemic control and thus may exhibit a smaller increase in HbA_{1c} levels. Thus, we take into account glucose levels of each respondent at T_1. Second, husbands and wives often have similar socioeconomic backgrounds, which may affect their choice of leisure activities and exposure to risk factors (e.g., poor eating habits, drinking, and smoking) (Falba & Sindelar, 2008; Wilson, 2002). Therefore, the observed direct association between spousal health and glycemic control may result in part from shared risk factors, many of which are unobserved. To deal with these methodological issues, we estimate two types of longitudinal multiple regression models: a lagged dependent variable model (to address initial glycemic levels) and a fixed effects model (to address persistent unobserved factors).

These models have a useful bracketing property that may help capture the true effect of interest (δ). Suppose a decline in spousal health of one point in our scale actually increases HbA_{1c} levels by δ percentage points. If the fixed effects model (FE) is correct and there are persistent unobserved factors that lead to deteriorating spousal health, but we mistakenly fit a lagged dependent variable model (LDV), then the estimated effect will tend to be too small

($\delta_{LDV} < \delta$). On the other hand, if the lagged dependent variable model is correct and the respondent's baseline glycemic levels are associated with deteriorating spousal health, but we mistakenly fit a fixed effects model, then the estimated effect will tend to be too large ($\delta_{FE} > \delta$). Under these circumstances the true causal effect will fall between the lagged dependent variable and the fixed effects estimates. In other words, δ_{LDV} is a lower bound and δ_{FE} is an upper bound for the true causal effect (δ). One would, of course, like to consider a more general model that includes these possibilities as special cases, but more than two waves would then be needed. (For a detailed proof of this result, see Angrist & Pischke, 2008, pp. 246-247).

Given that the fixed effects model estimates the extent to which changes in spousal health between two waves are associated with changes in glycemic levels, we also included changes in spousal health (i.e., differences in spousal health between the two waves) in the lagged dependent variable model in order to compare the results from the two models. Since there are gender differences in the association between spousal health and glycemic levels, we construct gender-stratified models. Nonetheless, we also explicitly test whether the association significantly differs by gender by pooling data from both genders and testing the significance of interaction terms.

Results

Table 1 presents descriptive statistics for all variables used in the analysis. Table 2 shows results from the lagged dependent variable models, which control for initial glycemic level. We observe that changes in glycemic levels by spousal health vary by gender ($p < 0.05$, not shown). For women we find that a deterioration of a husband's health of one step is associated with a significant increase of 0.13 percentage points in HbA_{1c} levels between waves ($p < 0.05$, model 2) but find no significant increase in HbA_{1c} levels after losing a husband in very good health ($p = 0.07$, model 2). For men we find no significant difference in glycemic levels by spousal health or becoming widowed (model 3). In all cases the estimates are adjusted for all other predictors in the model. For both men and women we find that changes in glycemic levels are negatively associated with baseline levels ($p < 0.001$), thus confirming the importance of controlling for the lagged outcome. Baseline spousal health status and death, however, are not significant in any model.

Table 3 shows results from the fixed effects models. Again, we find that the differences of interest vary by gender ($p < 0.05$, not shown). For women we find that a deterioration of husband's health of one step is associated with a significant increase of 0.15 percentage points in HbA_{1c} levels ($p < 0.01$, model 2) and that losing a husband in very good health is associated with a significant increase in glycemic levels of 0.76 percentage points ($p < 0.001$, model 2). For men we find no significant effect of a wife's deteriorating health—similar to results from the lagged dependent variable—but we find a significant effect of widowhood, with an estimated increase of 0.64 percentage points after losing a wife in very good health ($p < 0.05$, model 3). These results, however, do not allow the changes in HbA_{1c} to depend on initial HbA_{1c} levels.

For women, the effect of deteriorating husband's health is consistently estimated as an increase of 0.13 to 0.15 percentage points in HbA_{1c} levels by both strategies, suggesting that the true causal effect of spousal health for women may fall between 0.13 and 0.15. However, for men the estimates fall between −.015 and .014, so the true causal effect of spousal health may be essentially zero. The consequences of widowhood, however, are less clear, but losing a husband in very good health would result in an increase in HbA_{1c} levels between 0.31 and 0.76 percentage points. For men losing a wife in very good health would increase HbA_{1c} levels between 0.10 and 0.64 percentage points. In the lagged dependent variable model for women, the effect of husband's health deteriorating from very good to very poor is 0.52 percentage points (0.13×4), whereas the point estimate of the effect of losing a husband in very good health is only 0.31. In contrast, the fixed effects model for women produces a difference of 0.60 percentage points (0.15×4) when husband's health goes from very good to very poor, as compared with 0.76 when a husband in very good health dies. In all cases there seems to be very little increase in a woman's HbA_{1c} levels when she loses a husband in very poor health.

Discussion

Only a few studies have investigated the effect of declining spousal health on changes in glycemic levels for older adults. Our study has several advantages over this earlier work. First, while prior studies have used small clinical samples (Vitaliano et al., 1996), biomarker data collected by interviewers who were not medically trained, or population-based data that were cross-sectional (Das, 2013; Schulz et al., 1997), we used a nationally representative longitudinal sample and biomarker data collected by medical professionals. Second, based on social control theory, the stress process model, and cultural expectations of caregiving roles, we investigated whether gender moderates the association between spousal health and glycemic levels. Third, we employed two types of longitudinal multiple regression models (lagged dependent variable and fixed effects), which mitigate potential bias due to baseline glucose levels and unobserved time-invariant characteristics.

Several key contributions emerge from our findings. First, the association between declining spousal health and changes in glycemic levels differed by gender. Results from both models revealed that women whose husbands suffered a decline in health over the six-year period between survey waves experienced an increase in HbA_{1c} levels. The greater was the reduction in husbands' health, the greater was the increase in wives' HbA_{1c} levels. In contrast, wives' health was not significantly associated with changes in husbands' HbA_{1c} levels. Our findings follow a well-documented pattern, whereby spousal illness and disability in old age have a greater negative impact on women's than men's health (Pinquart & Sörensen, 2006; Yee & Schulz, 2000). In particular, our findings support a "pre-widowhood effect" on health, whereby an older adult whose spouse has a chronic or life-limiting condition may develop health problems before their spouse passes away (Williams, Sawyer, Roseman, & Allman, 2008). Yet, such an association appears to be less likely for older men.

Gender socialization—which explains gender differences in caregiving attitudes and behaviors (Miller, 1990; Sugiura et al., 2009)—may in part explain why spousal health has a

larger impact on glycemic changes for women. While married women often face exceptionally high demands for caregiving—such as rearing children, caring for their spouse, and looking after aging parents—married men face fewer of such demands (Spain & Bianchi, 1996). Therefore, caring for an ailing spouse may involve more personal health costs for women than men. In addition, the cultural context of the data may partly explain this finding. In Chinese culture, adult children (traditionally daughters-in-law) are expected to take care of an ailing parent (Chiou, Chen, & Wang, 2005). Thus, when a married woman falls ill, her husband is unlikely to become her primary caregiver. However, caregiving behavior may have changed recently owing to the rise of dual-career families and increasing utilization of nursing homes (Kao & McHugh, 2004).

We also found that the death of a spouse in very good health was associated with a substantial increase in glycemic levels for both genders, but losing a spouse in very poor health was associated with little increase in glycemic levels. Our findings are consistent with most prior studies of the widowhood effect on health (Goldman et al., 1995) and with a prior study showing that the death of a spouse is associated with high glucose levels of the other partner (Das, 2013). While previous studies have focused mainly on the effects of spousal death, our study revealed that these effects may vary by spousal health preceding the loss. Prior research has indicated that a conflicted or strained marriage is negatively associated with endocrine and immune functions for older adults (Kiecolt-Glaser et al., 1997). Studies based on the stress-relief model have found that caregivers feel relief after their care recipients die and show reductions in health risk behaviors (Schulz et al., 2001). Therefore, older adults who experience more psychological strain prior to the death of their spouse might exhibit a smaller change in glucose levels once their spouse passes away; yet, unanticipated spousal death may have an especially deleterious effect on the health of older adults (Carr, House, Wortman, Nesse, & Kessler, 2001).

Emotional distress following spousal death may affect glucose metabolism through stress hormones (e.g., catecholamines and cortisol), thus increasing glycemic levels (Kyrou & Tsigos, 2009; Wing et al., 1985). Adoption of negative coping strategies (e.g., heavy drinking) and loss of health-promoting benefits of marriage may explain why spousal death is associated with increased glycemic levels (Waite, 2009). However, the social, emotional, and behavioral pathways linking spousal death to glycemic levels may differ by gender. According to social control and support theories, marriage improves men's health through wives' health monitoring (e.g., health care utilization, physical activity, drinking alcohol, and smoking) (Umberson, 1992) but improves women's health through increasing their financial status, which, in turn, grants them access to better health-management resources (e.g., health insurance) (Hahn, 1993). Wives' illness or death might cause men to engage in health-damaging behaviors and lose some of the social ties that benefited their health (Umberson et al., 2013). Husbands' illness or death might increase financial hardship, which often leads to increased depressive symptoms for widows (Umberson, Wortman, & Kessler, 1992). To explore these pathways we conducted mediation analyses, but a small sample size precluded us from obtaining robust estimates. Future studies should seek to better understand these mediating mechanisms and how they differ by gender.

Because fasting plasma glucose is a marker frequently used to verify diabetic conditions (American Diabetes Association, 2006), we performed additional analyses using fasting plasma glucose in lieu of HbA_{1c}. We obtained similar results, though significance levels varied by model. The lagged dependent variable models showed that a decline in spousal health was significantly associated with an increase in fasting plasma glucose for women only, but findings from the fixed effects model were not significant (data available upon request). We suspect that the fixed effects model using fasting plasma glucose produced more erratic results because fasting plasma glucose is sensitive to non-compliance with the fasting requirement and generally has more measurement error than HbA_{1c} (Bonora & Tuomilehto, 2011), and fixed effects estimates are especially subject to measurement error (Angrist & Pischke, 2008).

Our study has several limitations. First, our findings are based on older cohorts in Taiwan, who lived in an era dominated by traditional caregiving attitudes; most older adults feel that women ought to be primary caregivers and that entering a nursing home is shameful (Kao & McHugh, 2004). Thus, our findings may not be generalizable to younger cohorts who may be more willing to utilize caregiving institutions. Second, because spousal heath was reported by a partner, the respondent's affective state and attribution tendencies may bias the results (Simonsick, 1993). Reporting biases may vary by gender: previous research suggests that women report their spouse's health more accurately than men (van Doom, 1998). Third, our study mitigated bias due to unobserved time-invariant variables, yet could not exclude potential bias due to unobserved time-varying characteristics. This potential confounding would be problematic for our main argument if both spousal health and respondent's glycemic levels are strongly influenced by the omitted variables (e.g., other family member's health or financial situation). Future research should consider including such variables when the relevant data are available. Finally, we cannot rule out reverse causality: a wife's elevated glycemic levels may lead to a decline in her husband's health. For example, a diabetic wife may serve her husband the same foods that caused her own blood sugar levels to spike, ultimately causing her husband's health to deteriorate. In supplementary analyses, we confirmed that elevated HbA_{1c} for women at T_1 was not significantly associated with a decline in husband's health at T_2 (data available upon request). This finding, however, does not lead to a firm conclusion about causal direction. More data points would be needed to adequately test this issue.

As life expectancy increases, individuals will be more likely to have a spouse fall ill or die during old age. Some older people may be ill equipped for such stressful life transitions and their after-effects. Our findings suggest that older women are particularly likely to experience increased glycemic levels if their husband's health deteriorates and that older adults who experience spousal death may have difficulty managing their glycemic levels. These findings have three implications for health interventions for older adults. First, health educators and medical professionals should be aware that older adults whose spouse falls ill or dies are at high risk for developing diabetes. Second, health care providers should consider targeting such older adults, encouraging regular medical check-ups to enable early detection and treatment of diabetes. Counseling and cognitive behavioral therapy, which can reduce perceived stress, may also help control glycemic levels. Third, to curtail harmful coping mechanisms, including disordered eating, poor sleeping habits, and drinking, gender-

specific interventions may be useful. Such interventions would ultimately reduce the downstream individual and societal costs of later life challenges.

References

American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2006; 29:S43–S48. [PubMed: 16373932]

Angrist, JD.; Pischke, J-S. Mostly harmless econometrics: An empiricist's companion. Princeton University Press; 2008.

Beverly EA, Miller CK, Wray LA. Spousal support and food-related behavior change in middle-aged and older adults living with type 2 diabetes. Health Education and Behavior. 2008; 35(5):707–720. [PubMed: 17456857]

Bonora E, Tuomilehto J. The pros and cons of diagnosing diabetes with A1C. Diabetes Care. 2011; 34(Supplement 2):S184–S190. [PubMed: 21525453]

Bourdel-Marchasson I, Doucet J, Bauduceau B, Berrut G, Blickle JF, Brocker P, Vischer UM. Key priorities in managing glucose control in older people with diabetes. The Journal of Nutrition, Health & Aging. 2009; 13(8):685–691.

Burton LC, Newsom JT, Schulz R, Hirsch CH, German PS. Preventive health behaviors among spousal caregivers. Preventive Medicine. 1997; 26(2):162–169. [PubMed: 9085384]

Carr D, House JS, Wortman C, Nesse R, Kessler RC. Psychological adjustment to sudden and anticipated spousal loss among older widowed persons. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2001; 56(4):S237–S248.

Chiou CJ, Chen I, Wang HH. The health status of family caregivers in Taiwan: an analysis of gender differences. International Journal of Geriatric Psychiatry. 2005; 20(9):821–826. [PubMed: 16116570]

Das A. Spousal loss and health in late life: moving beyond emotional trauma. Journal of Aging and Health. 2013; 25:221–242. [PubMed: 23271727]

Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. Physical Therapy. 2008; 88(11):1254–1264. [PubMed: 18801858]

Dungan KM, Braithwaite SS, Preiser J-C. Stress hyperglycaemia. The Lancet. 2009; 373(9677):1798–1807.

Fagot-Campagna A, Bourdel-Marchasson I, Simon D. Burden of diabetes in an aging population: prevalence, incidence, mortality, characteristics and quality of care. Diabetes and Metabolism. 2005; 31:5S35–35S52. [PubMed: 16415764]

Falba TA, Sindelar JL. Spousal concordance in health behavior change. Health Services Research. 2008; 43(1p1):96–116. [PubMed: 18211520]

Gallicchio L, Siddiqi N, Langenberg P, Baumgarten M. Gender differences in burden and depression among informal caregivers of demented elders in the community. International Journal of Geriatric Psychiatry. 2002; 17(2):154–163. [PubMed: 11813279]

Geronimus AT, Hicken M, Keene D, Bound J. "Weathering" and age patterns of allostatic load scores among blacks and whites in the United States. American Journal of Public Health. 2006; 96(5): 826–833. [PubMed: 16380565]

Glei DA, Goldman N, Lin Y-H, Weinstein M. Age-related changes in biomarkers: longitudinal data from a population-based sample. Research on Aging. 2011; 33(3):312–326. [PubMed: 21666867]

Goldman N, Korenman S, Weinstein R. Marital status and health among the elderly. Social Science and Medicine. 1995; 40(12):1717–1730. [PubMed: 7660185]

Goldman N, Lin I-F, Weinstein M, Lin Y-H. Evaluating the quality of self-reports of hypertension and diabetes. Journal of Clinical Epidemiology. 2003; 56(2):148–154. [PubMed: 12654409]

Gordon HS, Rosenthal GE. Impact of marital status on outcomes in hospitalized patients. Evidence from an academic medical center. Archives of Internal Medicine. 1995; 155(22):2465–2471. [PubMed: 7503606]

Hahn BA. Marital status and women's health: the effect of economic marital acquisitions. Journal of Marriage and the Family. 1993; 55:495–504.

Irwin M, Patterson T, Smith TL, Caldwell C, Brown SA, Gillin JC, Grant I. Reduction of immune function in life stress and depression. Biological Psychiatry. 1990; 27(1):22–30. [PubMed: 2297549]

Kao HFS, McHugh ML. The role of caregiver gender and caregiver burden in nursing home placements for elderly Taiwanese survivors of stroke. Research in Nursing and Health. 2004; 27(2):121–134. [PubMed: 15042638]

Kiecolt-Glaser JK, Dura JR, Speicher CE, Trask OJ, Glaser R. Spousal caregivers of dementia victims: longitudinal changes in immunity and health. Psychosomatic Medicine. 1991; 53(4):345–362. [PubMed: 1656478]

Kiecolt-Glaser JK, Glaser R, Cacioppo JT, MacCallum RC, Snydersmith M, Kim C, Malarkey WB. Marital conflict in older adults: endocrinological and immunological correlates. Psychosomatic Medicine. 1997; 59(4):339–349. [PubMed: 9251151]

Kyrou I, Tsigos C. Stress hormones: physiological stress and regulation of metabolism. Current Opinion in Pharmacology. 2009; 9(6):787–793. [PubMed: 19758844]

Lustman PJ, Anderson RJ, Freedland KE, De Groot M, Carney RM, Clouse RE. Depression and poor glycemic control: a meta-analytic review of the literature. Diabetes Care. 2000; 23(7):934–942. [PubMed: 10895843]

McEwen BS. Stress, adaptation, and disease: Allostasis and allostatic load. Annals of the New York Academy of Sciences. 1998; 840(1):33–44. [PubMed: 9629234]

Mehta KM, Yaffe K, Covinsky KE. Cognitive impairment, depressive symptoms, and functional decline in older people. Journal of the American Geriatrics Society. 2002; 50(6):1045–1050. [PubMed: 12110064]

Miller B. Gender differences in spouse caregiver strain: socialization and role explanations. Journal of Marriage and the Family. 1990; 52:311–321.

Pearlin LI, Aneshensel CS, LeBlanc AJ. The forms and mechanisms of stress proliferation: the case of AIDS caregivers. Journal of Health and Social Behavior. 1997; 38(3):223–236. [PubMed: 9343962]

Pinquart M, Sörensen S. Gender differences in caregiver stressors, social resources, and health: an updated meta-analysis. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2006; 61(1):P33–P45.

Ross CE. Reconceptualizing marital status as a continuum of social attachment. Journal of Marriage and the Family. 1995:129–140.

Schulz R, Beach SR. Caregiving as a risk factor for mortality: the Caregiver Health Effects Study. Journal of the American Medical Association. 1999; 282(23):2215–2219. [PubMed: 10605972]

Schulz R, Beach SR, Lind B, Martire LM, Zdaniuk B, Hirsch C, Burton L. Involvement in caregiving and adjustment to death of a spouse. JAMA: The Journal of the American Medical Association. 2001; 285(24):3123–3129. [PubMed: 11427141]

Schulz R, Newsom J, Mittelmark M, Burton L, Hirsch C, Jackson S. Health effects of caregiving: the Caregiver Health Effects Study: an ancillary study of the Cardiovascular Health Study. Annals of Behavioral Medicine. 1997; 19(2):110–116. [PubMed: 9603685]

Shaw J, Sicree R, Zimmet P. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Research and Clinical Practice. 2010; 87(1):4–14. [PubMed: 19896746]

Shaw W, Patterson T, Ziegler M, Dimsdale J, Semple S, Grant I. Accelerated risk of hypertensive blood pressure recordings among Alzheimer caregivers. Journal of Psychosomatic Research. 1999; 46(3):215–227. [PubMed: 10193912]

Siegel MJ, Bradley EH, Gallo WT, Kasl SV. The effect of spousal mental and physical health on husbands' and wives' depressive symptoms, among older adults: longitudinal evidence from the Health and Retirement Survey. Journal of Aging and Health. 2004; 16(3):398–425. [PubMed: 15155069]

Simonsick EM. Relationship between husband's health status and the mental health of older women. Journal of Aging and Health. 1993; 5(3):319–337.

Smith KP, Christakis NA. Social networks and health. Annal Review of Sociology. 2008; 34:405–429.

Spain, D.; Bianchi, SM. Balancing act: Motherhood, marriage, and employment among American women. Russell Sage; New York: 1996.

Sugiura K, Ito M, Kutsumi M, Mikami H. Gender differences in spousal caregiving in Japan. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2009; 64(1):147–156.

Thoits PA. Stress and health: Major findings and policy implications. Journal of Health and Social Behavior. 2010; 51(Suppl):S41–S53. [PubMed: 20943582]

Umberson D. Gender, marital status and the social control of health behavior. Social Science and Medicine. 1992; 34(8):907–917. [PubMed: 1604380]

Umberson D, Crosnoe R, Reczek C. Social relationships and health behavior across life course. Annual Review of Sociology. 2010; 36:139–157.

Umberson, D.; Thomeer, MB.; Williams, K. Family status and mental health: recent advances and future directions *Handbook of the Sociology of Mental Health*. Springer; 2013. p. 405-431.

Umberson D, Wortman CB, Kessler RC. Widowhood and depression: explaining long-term gender differences in vulnerability. Journal of Health and Social Behavior. 1992:10–24. [PubMed: 1619255]

van Doom C. Spouse-rated limitations and spouse-rated life expectancy as mortality predictors. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 1998; 53(3):S137–S143.

Vitaliano P, Russo J, Niaura R. Plasma lipids and their relationships with psychosocial factors in older adults. The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences. 1995; 50(1):P18–P24.

Vitaliano P, Scanlan J, Krenz C, Schwartz R, Marcovina S. Psychological distress, caregiving, and metabolic variables. The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences. 1996; 51(5):P290–P299.

Waite, LJ. Marital history and well-being in later life *International handbook of population aging*. Springer; 2009. p. 691-704.

Williams BR, Sawyer P, Roseman JM, Allman RM. Marital status and health: exploring pre-widowhood. Journal of Palliative Medicine. 2008; 11(6):848–856. [PubMed: 18715177]

Wilson SE. The health capital of families: an investigation of the inter-spousal correlation in health status. Social Science and Medicine. 2002; 55(7):1157–1172. [PubMed: 12365528]

Wing RR, Epstein LH, Blair E, Nowalk MP. Psychologic stress and blood glucose levels in nondiabetic subjects. Psychosomatic Medicine. 1985; 47(6):558–564. [PubMed: 4070524]

Yee JL, Schulz R. Gender differences in psychiatric morbidity among family caregivers: a review and analysis. The Gerontologist. 2000; 40(2):147–164. [PubMed: 10820918]

Table 1

Descriptive and summary statistics for variables used in the models, by gender

Variables	Women (n = 266)	Men (n = 331)
Age at T_1 (years), mean (SD)	65.97 (7.83)	66.63 (7.73)
Education (years), mean (SD)	3.77 (4.18)	6.95 (4.48)
Spousal health at T_1, mean (SD)	1.43 (1.05)	1.70 (1.13)
Spousal health at T_2, mean (SD)	1.64 (1.13)	1.68 (1.11)
Change in spousal health between T_1 and T_2, mean (SD)	0.21 (1.21)	−0.02 (1.24)
Widowed at T_1, %	32.33	8.46
Widowed at T_2, %	43.98	13.29
Widowed between T_1 and T_2, %	11.65	4.83
HbA_{1c} (%) at T_1, mean (SD)	5.72 (1.07)	5.55 (0.96)
HbA_{1c} (%) at T_2, mean (SD)	6.21 (1.05)	6.14 (1.09)
Change in HbA_{1c} (%) between T_1 and T_2, mean (SD)	0.49 (0.73)	0.59 (0.76)

Note. Spousal health is based on respondents who had a spouse at both waves (287 men and 149 women) and ranges from 0 (very good health) to 4 (very poor health). HbA_{1C} refers to glycosylated hemoglobin.

Table 2

Lagged dependent variable models predicting change in HbA_{1c} between two waves, by gender

Variables	Model 1: Total (n = 597)		Model 2: Women (n = 266)		Model 3: Men (n = 331)	
	***B* (SE)**	***P***	***B* (SE)**	***P***	***B* (SE)**	***P***
Change in spousal health between T_1 and T_2	0.039 (0.033)	0.235	0.129 (0.052)	0.014	−0.015 (.043)	0.731
Widowed between T_1 and T_2	0.176 (0.132)	0.184	0.311 (0.172)	0.072	0.095 (.216)	0.660
Spousal health at T_1	−0.012 (0.036)	0.733	0.071 (0.059)	0.233	−0.055 (.047)	0.239
Widowed at T_1	0.100 (0.103)	0.332	0.227 (0.138)	0.101	0.028 (.170)	0.870
HbA_{1c} at T_1	−0.223 (0.029)	< 0.001	−0.231 (0.039)	< 0.001	−0.211 (.042)	< 0.001
Age at T_1	−0.013 (0.004)	0.001	−0.011 (0.006)	0.080	−0.013 (.006)	0.016
Female	−0.114 (0.067)	0.088				
Education	0.001 (0.007)	0.883	0.014 (0.010)	0.177	−0.009 (.009)	0.351
Constant	2.701 (0.325)	< 0.001	2.307 (0.457)	< 0.001	2.786 (.453)	< 0.001

Note. *B* = unstandardized coefficient; SE = standard error; *P* = p-value.

HbA_{1c} = glycosylated hemoglobin.

Table 3

Fixed effects models predicting change in HbA_{1c} between two waves, by gender

Variables	Model 1: Total (N = 1194)		Model 2: Women (N = 532)		Model 3: Men (N = 662)	
	***B* (SE)**	***P***	***B* (SE)**	***P***	***B* (SE)**	***P***
Change in spousal health between T_1 and T_2	0.064 (0.034)	0.062	0.154 (0.052)	0.004	0.014 (0.045)	0.761
Widowed between T_1 and T_2	0.636 (0.154)	< 0.001	0.761 (0.190)	< 0.001	0.636 (0.266)	0.018
Constant	5.672 (0.071)	< 0.001	5.525 (0.114)	< 0.001	5.757 (0.089)	< 0.001

Note. *B* = unstandardized coefficient; SE = standard error; *P* = p-value; N = the number of observations over two waves.

HbA_{1c} = glycosylated hemoglobin.