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A PERSON-CENTERED APPROACH TO MODELING DIURNAL CORTISOL: THE IMPORTANCE OF DIFFERENCES IN AGE AND STRESSOR EXPOSURE

A Dissertation in

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ABSTRACT

Cortisol is a marker of HPA-axis activation that may be one of the biological mechanisms linking chronic stressors and heterogeneity in age-related health declines (e.g., Epel, 2009; Miller, Chen, & Cole, 2009). The aims of current dissertation were three-fold: 1) to identify person-centered profiles of diurnal cortisol among a national sample of U.S. adults, 2) to examine age-associated differences in diurnal cortisol profiles, and 3) to explore whether and how three different forms of stressful experiences differentially predict the relation between age and diurnal cortisol profiles. Growth Mixture Models with latent time basis were used to estimate daily profiles of diurnal cortisol among participants taking part in up to four consecutive days of saliva collection (N=1,622; age ranged between 34 and 87 years old). The 3-class solution provided the best model fit across all four days of saliva collection, with results further indicating a striking stability within estimated parameters of each profile across the entire study period. The majority of respondents exhibited a "typical" profile, characterized by relatively low awakening and bedtime levels, coupled with robust slopes following awakening and prior to bedtime. Approximately one-quarter of participants experienced an "elevated" profile, distinguished by a high morning level and blunted cortisol awakening response and diurnal slope. One-tenth of respondents exhibited a waking level that was similar to that of participants in the typical class, but remained remarkably "flat" throughout the rest of the day, showing weak cortisol awakening response and diurnal slope. In contrast to elevated and flat profiles, the typical profile was positively associated with younger age, higher self-rated health, and a greater likelihood of being employed, and negatively associated with minority status, cigarette smoking, and being male (p's<.05). After accounting for relevant control variables, the typical profile was associated with younger age (p<.001). Additional analyses demonstrated that report of greater

chronic stress in early midlife is associated with a lower probability of exhibiting a typical profile, and an increased risk of exhibiting a flat profile ($p<.001$). The current dissertation demonstrates the utility of the Growth Mixture Modeling approach to the study of diurnal cortisol, and supports previous work showing that older age, minority status, and poorer physical health and health behaviors are associated with a deviation from the robust waveform of diurnal cortisol. Furthermore, results show that chronic stress in early midlife may increase the likelihood of a flatter rhythm of diurnal cortisol–a profile that is typically associated with older adulthood.

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CHAPTER 1: INTRODUCTION

Overview

Although not an inevitable trajectory, the gradual deterioration of physical health from its peak in young adulthood is a classic depiction of aging. According to this representation, aging involves profound physiological declines in many health-related systems of the body, including the systems driving the functioning of respiratory, endocrine, cardiovascular, and immune systems. Among many other changes, aging adults commonly experience increased susceptibility to infections, reduced visual acuity, heightened rigidity of the lungs, decreased bone density, increased systolic blood pressure, poorer hearing sensitivity, and lowered muscular strength and endurance (for review, see Schaie & Willis, 2011). Older age appears to be associated with differences in one marker of hypothalamic-pituitary-adrenocortical (HPA) axis functioning–the diurnal rhythm of cortisol (Epel, 2009; Sapolsky, Krey, & McEwen, 1986). This hormone is particularly responsive to stress and has been hypothesized to be one of the biological mechanisms linking health and environmental insults (e.g., Cohen, Kessler, & Gordon, 1995; Miller, Chen, & Cole, 2009). Although not a direct measure of health, dysregulated diurnal cortisol levels have been associated with a number of illnesses, including coronary heart disease, frailty, symptoms of burnout, depressive symptoms, chronic fatigue, and rheumatoid arthritis. This circadian cycle has been hypothesized to be an important indicator of physiological activation that may be a mechanism driving some of the heterogeneity in age-related health declines (Epel, 2009; Miller, Chen, & Cole, 2009; Miller, Chen, & Zhou, 2007).

It appears that ontogenetic and environmental factors are responsible for the average trend in physiological functioning–exhibited by losses and decline over time (Baltes, 1997). However, it is important to point out that the physical aging process is characterized by

remarkable heterogeneity across individuals, and that deteriorating health that is typically associated with chronological aging represents an imperfect statistical association (Wohlwill, 1973). The life-span developmental approach advocates a careful re-examination of the assumed relationship between chronological aging and health declines (Baltes, Lindenberger, & Staudinger, 2006). To this end, the presence or absence of stress has been noted as a possible cause for no single rate of aging that applies universally. Physical stressors provide one cause of the ultimate age-related health outcome, mortality. A case in point is a recent report showing that fine particle pollution, an environmental stressor that is a by-product of diesel engines, causes 9,200 premature deaths of Californians annually (California Air Resources Board, 2010). In addition to insults in the physical environment, it appears that stressful events in the psychosocial environment may also influence the aging process. Psychosocial stressors generate costs for mental health (e.g., Breslau et al., 1998), capacity for emotion regulation (e.g., Liston, McEwen, & Casey, 2009), and physical health (e.g., Boscarino, 1997; DeLongis, Folkman, & Lazarus, 1988; Kiecolt-Glaser et al., 1996).

According to Baltes and colleagues, the substantive objectives of research employing the life-span developmental perspective may strive for understanding any of the following four aspects of development: 1) the structure and sequence of life-span development, 2) the links between events and processes over time, 3) the mechanisms and contextual factors of development, such as biological, psychological, social, and environmental characteristics, and 4) the extent to which development is plastic or modifiable (Baltes, 1997; Baltes et al., 2006). The current dissertation employs two of these objectives. The overarching goal is to identify person-centered profiles of diurnal cortisol, as well as examine their association with age and psychosocial stress. In carrying out this goal, I illustrate an application of the life-span

developmental approach to one parameter of physiological activation and functioning. More specifically, following the overview of related literature, Chapter 1 proposes a dissertation with three aims: 1) identification typical patterns of diurnal cortisol among a national sample of adults in the United States, 2) description of age differences associated with these patterns, and 3) examination of how three different dimensions of psychosocial stressors moderate age differences in diurnal cortisol profiles. Thus, in addition to the first aim of determining common person-centered profiles of cortisol across the day, this dissertation explores typical age differences associated with these profiles, and examines how the context of psychosocial stressors generates interindividual differences in the relation between chronological age and diurnal cortisol. Moreover, the current dissertation distinguishes between the effects of different stressor types, in order to incorporate the multidimensional and complex nature of the stress process.

The Stress Process

The study of the stress process has passed through the inquiry of many disciplines, with Hippocrates first noting the existence of "ponos," or the general suffering common to many diseases (as cited by Baum, Gatchel, & Krantz, 1997). Walter Cannon first noted the capacity of external events, such as psychological threats, to induce a temporary heightened arousal of the body (Cannon, 1932), and Hans Selye later coined the term "stressor" to describe this arousing agent, or "naturally 'that which produces stress'" (Selye, 1976, p. 78). Selye posited that stressors are external to the animal, and produce a nonspecific stress response. Since that time, the experience many now refer to as "stress" has acquired a seemingly high face validity among the lay public (Monroe, 2008); yet this word is often used loosely, is often *mis*used, and is

misunderstood to be everywhere, and responsible for most diseases, particularly those without a known biological etiology (Wheaton, 1999).

Decades of theoretical and empirical examination of stressful experiences have provided a more sophisticated understanding of the stress experience. One view that provides a way to delineate the stress process into smaller components, does so according to the lines along which different academic disciplines have traditionally examined the stress process: the external stressful event, the individual's psychological response, and the individual's physiological response (Cohen et al., 1995). This description explains that the stress process has been traditionally understood as three different, relatively non-overlapping components: the objective component consisting of a stressful agent, subjective appraisal of the event and one's ability to cope with it, and the physiological reaction to the event. The following section reviews fundamental research on two of these components: the concept of a stressful agent, or a stressor, and the physiological response to the stressor.

Stressors

Modern researchers have noted that there is nothing necessarily event-like about stressors. Some stressors are indeed events, whereas others are better understood as chronic conditions or continuous states. Thus, rather than referencing one acute event, some stressors may also refer to "conditions of threat, demands, or structural constraints that, by their very occurrence or existence, call into question the operating integrity of the organism" (Wheaton, 1999, p. 177). Further, two dimensions have been found to play important roles in determining health and well-being: the temporal dimension (e.g., stressor timing, frequency, duration) and the dimension of severity (e.g., subjective magnitude of stressor-related threat).

In addition, types of events or conditions (e.g., an argument, experienced within the work domain, appraised as threatening to one's finances) are also important to consider when examining the consequences of stressors (Almeida, 2005). Finally, it is critically important to differentiate between a stressor and an individual's reactivity to a stressor, a distinction that is often blurred in lay speech and popular media. Stressor exposure refers to the likelihood of experiencing a stressor; indeed, it appears that some individuals are more likely to be exposed to stressors, given their resilience and vulnerability factors (Almeida, 2005). In contrast, reactivity is the likelihood of an individual exhibiting stressor-generated psychological or physical distress, which also partly depend on resilience and vulnerability factors. Stressor reactivity can be operationalized by estimating biological and emotional responses to a stressful event. Although individual characteristics inform both exposure and reactivity constructs, indicating that these two constructs are not perfectly discrete, the distinction provides a useful heuristic for understanding the stress process.

Forms of Stressful Events

Traumatic events are the most acute and disruptive of stressor forms, and include man-made and natural disasters and catastrophes (Pearlin, 1999). Chronic stressors, conversely, might lack a clear onset date, and might represent persistent environmental constraints (Wheaton, 1999). In general, the most notable difference between chronic stressors and traumatic events is the length of time over which they unfold; however, they typically also vary in suddenness of onset, development and offset. Life events are relatively acute and discrete experiences that more common than traumas, and are comprised of events such as a death of a pet, divorce, marriage, or sudden unemployment. These stressors are less abrupt and disruptive then traumas, but appear

nearest to traumas on the stressor-chronicity continuum because they often beget significant life changes, and are often characterized by rapid onset, development and offset.

Daily stressors also represent relatively discrete events, whose position on the stress-chronicity continuum is typically somewhere between chronic stressors and traumatic events. Stressors of this form are characterized by lower severity than life events and a shorter duration than chronic stressors. These stressors refer to discreet events, such as an unanticipated car breakdown, and are defined as routine day-to-day challenges and arguments (Almeida, 2005). The operationalization of this form of stressor was developed to distinguish the daily event from other information, such as the psychological distress that may be associated with day-to-day hassles. One measure of daily stressors, the Daily Inventory of Stressful Events (DISE, Almeida, Wethington, & Kessler, 2002), is a semi-structured inventory of daily stressors, that was developed to examine daily stressors as they are experienced distinctly from stressor outcomes and stressors of other forms. Daily stressors are micro, episodic events that have a direct and unique impact on physical health well-being (Serido, Almeida, & Wethington, 2004), and may accumulate to generate greater importance than stressors that are more infrequent (Almeida, 2005).

Although a number of studies examining heterogeneity in health or aging processes have considered the role of one type of stressor, such as caregiving (e.g., Kiecolt-Glaser et al., 1996), socioeconomic adversity (e.g., Miller, et al., 2009), or trauma (e.g., Yehuda et al., 1995), few (e.g., Serido, Almeida, & Wethington, 2004) have endeavored to estimate unique effects of different types of stressors. Rather than selecting one form of stressors for analyses, the current dissertation examines the unique contribution of each stressor type. The current dissertation employs a careful distinctions between stressor forms (i.e., life events, chronic stressors, daily

stressors) in order to formally assess the multidimensional impact of stressors on the association between age and diurnal cortisol.

Physiological Response to Stressors

Cannon's (1932) seminal observations on the "fight-or-flight" response initiated investigations into how the organisms are alerted to take action in light of threatening circumstances. The fight-or-flight metaphor describes the behavioral response to a stressor: the tendency of the organism to either fight, in instances of a realistic chance of conquering the stressor in question, or flee, in cases where a threat is perceived to be too overwhelming.

Cannon noted that following a psychologically or physiologically challenging event, the body experiences a near-immediate and adaptive mobilization of the autonomic nervous and endocrine systems, known in combination as the activation of the sympatho-adrenal-medullary (SAM) axis: sympathetic neurons and the adrenal medulla secrete catecholamines epinephrine and norepinephrine. These neurotransmitters are responsible for producing the short-term effects that are typically associated with the experience of an acute challenge, such a fast heartbeat, increased sweating, constricted blood vessels, and rapid breathing (for review, see Klein & Corwin, 2007). These physiological changes increase the amounts of distributing oxygen and glucose, and provide an increased blood flow to muscles. Released catecholamines travel through the bloodstream and bind to epinephrine and norepinephrine receptors of relevant organs, stimulating or inhibiting the organ's activity accordingly. The effect of these neurotransmitters varies based on the organ they bind to, and this variation appears to be due to the type, density and activity in the available neurotransmitter receptors of the organs.

A model for the more gradual and sustained activation mainly driven by the endocrine system was first discussed by Selye (1956), and has come to be known as the HPA-axis. Upon

perceiving a stressor the cerebral cortex alerts the neurons of the paraventricular nucleus of the hypothalamus to release the corticotrophin releasing hormone (CRH) into the hypothalamic-pituitary portal blood flow system (for reviews, see Dickerson & Kemeny, 2004; Miller, Chen, & Zhou, 2007). CRH travels through the hypophyseal portal circulation to the anterior pituitary gland, where it stimulates the release of adrenocorticotropin hormone (ACTH). ACTH travels through the body to the adrenal cortex, where it initiates glucocorticoid release, including that of cortisol.

As an integral component of HPA-axis activation, cortisol is one of the primary hormones to mobilize the body's response to stress (Chrousos & Gold, 1992). Stress-related cortisol release is observed 15-20 minutes following cessation of the stressor, due to the cascade of hormonal events that need to occur prior to cortisol release from the adrenal cortex. Ultimately, cortisol mobilizes energy stores, has protective functions, and serves as an anti-inflammatory hormone (Chrousos & Gold, 1992; for a review, see Dickerson & Kemeny, 2004). The termination of cortisol release occurs through a negative feedback mechanism, which involves the hormone itself. After its rise in response to ACTH stimulation, cortisol binds to various glucocorticoid receptors, including those in the pituitary and the hippocampus (Baum, Gatchel, & Krantz, 1997). The process of binding to pituitary and hippocampal receptors serves as a negative feedback loop for the HPA-axis, whereby it signals the beginning of inhibition of CRH, and, consequently, cortisol.

Aim 1: Identification of Diurnal Cortisol Profiles

The striking diurnal pattern of cortisol release results from intermittent pulsatile bursts of cortisol secretion throughout the day (e.g., Weitzman et al., 1971). When the levels resulting from these bursts are smoothed, the average pattern is characterized by a marked peak, or the

cortisol awakening response, approximately 30 to 45 minutes after waking in the morning. This peak is followed by a gradual drop in levels throughout the rest of the day, often referred to as the diurnal slope. Level of cortisol continues to decline following sleep initiation, reaching its nadir, or lowest point, in the early morning hours, approximately around 2300 to 0200 hours. It then begins to rise again, reaching a moderately high level upon awakening (e.g., Van Cauter, Leproult, & Kupfer, 1996).

The nonlinear and dynamic nature of diurnal cortisol levels are both fascinating and challenging to study (Clow, Evans, & Hucklebridge, 2004). Although cortisol release occurs in response to physical or psychological stressors (for review, see Dickerson & Kemeny, 2004), a persistent diurnal rhythm of cortisol release emerges consistently, regardless of stressor experiences (e.g., Van Cauter et al., 1996; Weitzman et al., 1971), and even in the absence of any environmental zeitgebers. This diurnal waveform is moderately predetermined by heredity (Bartels et al., 2003; Franz et al., 2010), and is partially preprogrammed by the body's central biological clock (for review, see Van Cauter & Buxton, 2001), yet the rhythm is also dynamic in its response to many chronic and episodic behaviors and environments (Dickerson & Kemeny, 2004). Unlike the stress-responsive increases in cortisol, the cortisol awakening response appears to be primarily regulated by a preprogrammed endogenous circadian pacemaker located in the hypothalamic suprachiasmatic nucleus (for reviews, see Akerstedt & Levi, 1978; Clow et al., 2010; Fries, Detternborn, & Kirschbaum, 2009; Van Cauter & Buxton, 2001). However, as described below, several other factors influence the cortisol awakening response and cortisol rhythm throughout the rest of the day, including the negative feedback mechanisms of the HPA-axis described above.

Theoretical Significance of the Diurnal Rhythm

Akerstedt and Levi (1978) note that the near-sinusoidal diurnal patterns of biological systems often exhibit considerable amplitude, and should be examined, as they may represent a classical concept of homeostasis. Although the exact functions of diurnal cortisol are still unknown (e.g., Clow et al., 2010; Fries et al., 2009), there have been a number of proposals explaining the theoretical significance of cortisol awakening response and diurnal slope.

The majority of research on the functional significance of diurnal cortisol has investigated the cortisol awakening response. Recent reviews acknowledge that the theoretical and practical significance of the cortisol awakening response are still unknown (e.g., Clow et al., 2010; Fries et al., 2009). Proposals explaining its purpose have included the mobilization of the body's energy reserves in light of awakening in the morning (Pruessner et al., 1997), the switching of immune system to daytime activity (Huckelbridge et al., 1999), and the anticipation of events of the upcoming day and the "orientation about the self in time and space" (Fries et al., 2009). The degree of subsequent decline of cortisol throughout the day, or diurnal slope, has been hypothesized to represent an ability to disengage from stressful events at the end of the day, as well as an intact HPA-axis negative feedback loop (for reviews, see Heim, Ehlert, & Hellhammer, 2000; Miller et al., 2007).

Patterns of Diurnal Cortisol

Cortisol level. Previous empirical work suggests that a number of experiences modulate diurnal cortisol expression. A selected review of results of relevant studies, according to cortisol media, appears in Table A-1 (see Appendix A). One relatively consistent finding is the association between stressors and high integrated or mean cortisol level across the day among adults in midlife and older age. For example, integrated or average cortisol values have been

observed among the following individuals: employed women with higher perceived home stress (Luecken et al., 1997), adults reporting higher early-life socioeconomic adversity (Miller et al., 2009), adults with greater effort and greater effort-reward imbalance (Eller, Netterstrøm, & Hansen, 2006), and British civil servants experiencing more severe stressors (Kumari et al., 2010). Furthermore, higher salivary cortisol level has been observed on days characterized by stressful experiences, such as competition days among dancers (Rohleder, Beulen, Chen, Wolf, & Kirschbaum, 2007), and days when U.S. adults experience at least one daily stressor (Stawski, Almeida, & Cichy, 2011). There appear to be several exceptions to this line of research, whereby PTSD patients (e.g,. Yehuda et al., 1990) and Chicago adults who did not attain a high school education (Dowd et al., 2011) exhibit lower overall cortisol levels. Further, several studies have demonstrated a non-significant association between overall cortisol level and stressors, such as the studies examining perceived stress at work (e.g., Luecken et al., 1997).

Studies exploring cortisol levels within particular intervals of time within day generally illustrate that stressors are associated with lower awakening cortisol level and higher afternoon, evening and overnight cortisol levels. One early study suggested that high perceived work load is associated with lower morning and higher afternoon plasma cortisol levels among middle-aged male NASA administrators (Caplan, Cobb, & French, 1979). Later studies confirmed this link between stressors and salivary cortisol. Among middle-class mothers of toddlers in early midlife, lower awakening cortisol is associated with having a younger toddler and working a greater number of hours per week (Adam & Gunnar, 2001). Mothers of adolescents and adults with autism spectrum disorder exhibit lower awakening cortisol than mothers of adolescents and adults without disabilities (Seltzer et al., 2010). Higher home responsibility is related to higher evening cortisol among physicians of both sexes (Bergman, Ahmad, & Stewart, 2008). Unlike

their husbands, who do not exhibit a significant correlation between marital satisfaction and diurnal cortisol, upper-middle class women from dual-earner families demonstrate a relation between lower awakening cortisol higher marital satisfaction (Saxbe, Repetti, & Nishina, 2008). Greater workload days were associated with higher evening cortisol across both sexes in this study. Research on trauma shows that Holocaust survivors with PTSD exhibit lower waking and 8:00am cortisol levels and higher 8:00pm cortisol levels, than Holocaust survivors without PTSD or a comparison sample of Jewish older adults who did not experience the Holocaust (Yehuda, Golier, & Kaufman, 2005). Finally, several studies have not confirmed the association of stressors with lower morning cortisol and higher cortisol in the later part of the day. These results include the findings of non-significant associations between cortisol levels and 1) socioeconomic status among older men from Taiwan (Dowd & Goldman, 2006), 2) marital satisfaction in men (Saxbe et al., 2008), and 3) work demands and control among middle-class adults (Eller et al., 2006).

Diurnal rhythm. Some studies suggest that a disruption in the dynamic quality of cortisol across the day is crucial to understanding diurnal cortisol. This disruption can be exhibited by a relatively unpronounced profile of diurnal cortisol. The temporal nature of the stress is crucial here, with the initial response to an acute stressor being associated with a greater mounting of the cortisol awakening response, as demonstrated by increased cortisol awakening response among competitive ballroom dancers prior to a tournament when compared to a non-competition day (Rohleder et al., 2007). In contrast, repeated assault afforded by chronic stressors may be associated with a weaker overall pattern, with an attenuated cortisol awakening response and diurnal slope over time (Fries, Hesse, Hellhammer, & Hellhammer, 2005).

In line with this reasoning, the hypocortisolism model posits that persistent stress results in an "over-adjustment" on the part of the HPA-axis, which may be exhibited by a reduction in the number and activity of glucocorticoid receptors, a reduction in biosynthesis of cortisol, and/or increased sensitivity to glucocorticoids (Fries et al., 2005). As a result, basal diurnal cortisol levels may appear blunted, with a failure to activate the HPA-axis in the morning, and/or a failure to deactivate it in the evening, resulting in a relatively flat diurnal slope (Fries et al., 2005; Gunnar & Vazquez, 2001; Heim, Ehlert, & Hellhammer, 2000).

Indeed, some research substantiates this conclusion. Above-mentioned studies supporting lower morning level (when coupled with lower morning peak values) and higher afternoon/evening levels in light of stressors provide evidence for this model, as these values can cause blunted cortisol awakening response and diurnal slope. However, low cortisol level at morning peak (15-45 minutes after waking) can also produce this flattened pattern, sometimes even in concert with cortisol levels that are relatively high upon awakening or low in the evening. The description of these patterns as blunted/flattened is often used interchangeably and the patterns are rarely distinguished. The description of flat or blunted cortisol rhythm has been applied to 1) lower 30min post-waking value coupled with high levels in the later part of the day (e.g., O'Connor et al., 2009; associated with higher perceived stress among women), 2) lower total cortisol with a flatter overall slope, driven by lower cortisol from 15 to 45 minutes post-waking, with no significant differences in waking or evening values (e.g., Lasikiewicz, Hendrickx, Talbot, & Dye, 2008; associated with poorer metabolic profile, but not perceived stress), 3) flatter cortisol awakening response, driven by a weaker decline during the interval of 30 to 60 minutes post-waking, with no significant differences in waking or evening levels (e.g., Ranjit, Young, & Kaplan, 2005; associated with greater material hardship among women), 4) a

flatter diurnal slope that further decelerates in linear decline, driven largely by higher evening levels, with no differences in waking level or cortisol awakening response (Seltzer et al., 2009; associated with having a child with a disability), and even as 5) more robust cortisol awakening response, followed by little drop in cortisol level across the rest of the day (Kumari et al., 2010; associated with a more severe stressor on day of sampling). There appear to be some exceptions to the link between stressors and cortisol awakening response and diurnal slope, as in work indicating that socioeconomic adversity early in life does not appear to be associated with adult cortisol awakening response or diurnal slope (Miller et al., 2009).

Thus, empirical work generally supports the proposal that a disruption in the cortisol rhythm can be exhibited by a relatively unpronounced profile of diurnal cortisol; this weak cortisol rhythm has been observed among individuals undergoing traumatic or chronic stressors (Adam & Gunnar, 2001; Bergman et al., 2008; Ranjit et al., 2005; Seltzer et al., 2009), although many of these studies have a limited sample size. There is a great variability in operationalization of blunted cortisol rhythm, which produces great heterogeneity in results linking stressors and cortisol rhythms and levels across studies. Thus, an important next step is to synthesize this literature by simultaneous identification of multiple parameters of diurnal cortisol, among a sufficiently large and heterogeneous sample of participants.

Identification of Person-Centered Profiles of Diurnal Cortisol

Review of literature demonstrates that most studies examining diurnal cortisol have focused on one or two of its aspects (e.g., the cortisol awakening response, evening level , etc.). Various researchers have argued for a distinction between the shape of the curve and the total output of cortisol (e.g., Clow et al., 2004, Clow et al., 2010; Adam & Kumari, 2009), as these indicators of cortisol may be differentially associated with health and other outcomes. However,

total level and the form of slopes of the cortisol pattern co-occur in the body simultaneously, and it is important to recognize the rhythm in its full complexity.

Several researchers have argued for the need to determine person-centered profiles of diurnal cortisol (e.g., Van Ryzin, Chatham, Kryzer, Kertes, & Gunnar, 2009), which would include simultaneous modeling of the level and shape of cortisol curves across the day, but the empirical literature on this topic is in its nascency. Using *K*-means Cluster Analysis to identify cortisol patterns among a sample of 147 middle-aged participants, Lasikiewicz and colleagues (Lasikiewicz et al., 2008) extracted two cortisol clusters: a group exhibiting a typical cortisol profile (22% of sample), and a less healthy group (78% of sample). Compared to the former cluster, participants in the latter cluster exhibited similar waking and evening levels, but dramatically lower morning peak values, resulting in lower AUC, and blunted cortisol awakening response and diurnal slope. This larger group also experienced poorer sleep quality, greater insulin resistance, and greater waist-hip ratio. The clusters extracted in this analysis did not appear to be associated with perceived stress.

Another study utilized Latent Variable Mixture Modeling on one day of cortisol data from 2801 older adults participating in the Whitehall II study (Kumari et al., 2010). The two-group solution was chosen, with the typical cortisol profile (73% of sample), and a less healthy profile (27% of sample), where participants experienced similar awakening levels, but a more robust cortisol awakening response, followed by little drop in cortisol levels across the rest of the day, and resulting in higher evening cortisol. Membership in the latter group was related to shorter sleep, slower walking speed, being male, being a cigarette smoker, and experiencing a more severe stressor on the day of cortisol sampling. Statistics related to model evaluation (e.g., Log-likelihood, BIC, Lo-Mendell-Rubin test) indicated that the 3-class solution provided a

better fit to the data. Further, additional tests using bootstrapping did not replicate their chosen solution, suggesting that the 2-class solution may represent a local maximum (Nylund, Asparouhov, & Muthén, 2007).

Aim 1 Hypotheses

Few studies have utilized a person-centered approach to identify profiles of diurnal cortisol. Inconsistency across results of studies that utilized this approach indicates the necessity for further research on this topic. This dissertation posits that an important next step is a parsimonious assessment of various parameters of the diurnal rhythm (e.g., overall level, cortisol awakening response, diurnal slope), in order to estimate how these components co-occur within individuals, rather than independently. To carry out this aim, Group Mixture Modeling (GMM) was carried out on diurnal salivary cortisol data provided by a national sample of adults residing in the United States.

Although research to date does not provide clear guidance on profiles of cortisol that are common, I expected that the best-fitting GMM would suggest at least three cortisol profiles. I hypothesized that the first profile, representing the "typical" diurnal cortisol pattern, would begin with a relatively low awakening level, followed by a 50-100% increase (i.e., a morning increase in free salivary cortisol among healthy participants according to Pruessner et al., 1997) represented by the cortisol awakening response, followed by steep, decelerating decline, ending in a bedtime level that is lower than the awakening cortisol level. I also expected to observe two types of blunted profiles, with respect to the "typical" profile: a 1) "low-flat" group, characterized by relatively low levels across the day, with blunted cortisol awakening response and diurnal slope, and a 2) "high-flat" group, characterized by relatively high levels, but also blunted cortisol awakening response and diurnal slope.

Aim 2: Age Differences in Cortisol Profiles

Research indicates that some age-related differences and changes may be consistently observed in regulation of biological indicators of the stress-responsive HPA-axis (e.g., Chahal & Drake, 2007). The following sections discuss the possibility that cortisol may be one of the mechanisms driving heterogeneity in age-related health declines, and highlight possible age differences and age changes in rhythm of diurnal cortisol.

Theories of Aging

Researchers have proposed various models in order to account for the meaning and reasons for age-related physical declines (for review, see Kirkwood, 2005). On one end of the spectrum is the position arguing for pre-programmed aging, which posits health decline to be a genetically encoded part of aging. One empirical line of research supporting this position consists of findings examining telomere loss, which suggest a pre-programmed limited replicating potential in every cell due to age-related deterioration in telomeres, repetitive DNA sequences protecting each cell's chromosome (Kim, Kaminker, & Campisi, 2002).

On the other hand, it has also been noted that age is merely a proxy–one of several useful temporal axes for understanding healthy functioning (Spiro, 2009), and that there may be no such thing as aging outside of life experiences and disease (Peto & Doll, 1997). The wide variety of stability and change in physical health and well-being experiences over the adult years have prompted researchers to use metrics other than chronological age to assess the extent of aging exhibited by individuals. Researchers have employed alternative axes for tracking the aging process in addition to chronological time, including distance-to-death (e.g., Diehr, Williamson, Burke & Psaty, 2002) and distance-to/from-disease onset (e.g., Ram, Gerstorf, Fauth, Zarit, & Malmberg, 2010).

These studies have illustrated that alternative metrics of aging are more accurate than chronological age in predicting health declines. Although this has not been determined conclusively, chronological age may simply be a marker, and only one of the causal factors of decline often associated with aging. As discussed in further detail in Aim 3, according to Epel (2009), the experience of chronic stressors may lead to an impaired return to baseline, which is similar to the effect of aging on the HPA-axis. She writes that aging may associated with higher average level of cortisol, an exaggerated stressor response, and an inability to return to homeostasis (Epel, 2009).

Cortisol as a Mechanism Linking Age, Stress and Health

Although adaptive in the short term, repeated and prolonged HPA-axis activation can have detrimental effects on health, and can lead to dysregulation of the negative feedback loop, resulting in elevated levels of cortisol in the bloodstream (Dickerson & Kemeny, 2004). More specifically, prolonged stress exposure appears to uncouple cortisol from its ability to inhibit further CRH and ACTH secretion, which leads to overproduction of cortisol. According to the glucocorticoid cascade hypothesis (Sapolsky et al., 1986) cortisol may be the mechanism of stress "getting under the skin." The authors propose that repeated cortisol activation that result from high stressor accumulation, impairs the negative feedback of cortisol activation, thereby producing ill health.

Older age is associated with greater stressor accumulation, and, therefore, a greater likelihood of impairment in the above-described negative feedback loop. Sapolsky and colleagues (Sapolsky et al., 1986) review evidence of a dramatic impairment in termination of corticosterone production (i.e., a cortisol equivalent among non-human animals) among older rats. The authors posit that an inability to terminate the stress response is due to various stress-

related changes that occur in the aging brain. For example, one possible mechanism may be wear and tear-related reduction in protein glucocorticoid-binding receptors, which provide the connection between glucocorticoids and the target tissue they influence. Indeed, they review that half of the glucocorticoid binding sites disappear in the hippocampus of the aging rat. They also propose reductions in receptor affinity to bind with cortisol in the amygdala, and a partial loss in the number of receptors and neurons in the CA3 section of the hippocampus. Thus, this model proposes a vicious cycle whereby high cortisol levels destroy the feedback mechanisms that keep cortisol levels in check, resulting in an age-related attenuation of cortisol reductions following stressor termination.

Aging and Diurnal Cortisol

Several studies have identified age differences and changes–often interpreted as decline–in various parameters of diurnal cortisol, including average levels across the day, output during specific points and intervals of the day, dynamic patterns in rates of increase and decrease of cortisol over specific intervals and across the day, and in day-to-day variability of levels and diurnal rhythms (for reviews, see Chahal & Drake, 2007; Epel, Burke, & Wolkowitz, 2009).

A selected review of studies relevant to the age-diurnal cortisol link appears in Table A-2 (see *Appendix A*). Recent reviews (e.g., Fries et al., 2009) acknowledge that the influence of age on diurnal cortisol, particularly in larger studies, have been inconsistent. Age appears to be associated with a 20-50% increase in basal cortisol level from the age 20 to 80 years old (Chahal & Drake, 2007; Jacobs, Mason, Kosten, Brown, & Ostfeld, 1984). There is some evidence indicating that with increasing age, cortisol exhibits a raised hypocortisolemic profile: higher awakening levels with an attenuated cortisol awakening response (e.g., Kudielka & Kirschbaum, 2003; Van Cauter, et al., 1996; but see Almeida, et al., 2009, Wüst et al., 2000), and a flatter

decline in the second part of the day, resulting in higher cortisol levels at evening and nadir (Deuschle et al., 1997; Van Cauter, et al., 1996).

According to my review, only two published studies have analyzed age differences across the entire pattern of diurnal cortisol among adults using a person-centered approach. Each study settled on a 2-profile solution, although results from one indicated that more than the two-class solution would provide a better fit. Lasikiewicz and colleagues (Lasikiewicz et al., 2008) used *K*-means Cluster Analysis and identified two cortisol profiles among 147 middle-aged participants, ranging in age between 35 and 65 years old. Although the number of collected saliva samples was impressive (i.e., eight in total: at waking, at 15, 30 and 45 minutes, and at 3, 6, 9 and 12 hours post-waking), the sample size was relatively small for an analysis of heterogeneous subgroups. Further, these data were combined from two different samples, with distinct study designs (i.e., participants collecting one day of saliva from one subsample were pooled with participants who provided data on up to three days of salivary cortisol). These analyses revealed a "typical" pattern, and a "low-blunted" pattern, such that the "low-blunted" profile (*n*=114, 78% of sample) was characterized by low overall levels, and flatter cortisol awakening response and diurnal slope. Although this membership in this profile was associated with a poorer metabolic profile, it was not directly related to age or stress.

Kumari and colleagues (Kumari et al., 2010) used Latent Variable Modeling on data based on up to six points of saliva collection within one study day (i.e., waking, and at 30 minutes, 2.5 hours, 8 hours and 12 hours after waking, and at bedtime) among an impressive number of nearly 3000 participants. They identified a 2-class solution, despite evidence from model fit statistics (*vis*., sample-size adjusted BIC values, adjusted LRT *p*-values) that a larger number of groups may have provided better fit to these data. Despite their large sample, they

found that age is only approaching significance in relation to class membership. There was a trend for an association between older age and a greater likelihood of exhibiting a "raised" cortisol pattern. This pattern was characterized by higher cortisol AUC, steeper cortisol awakening response, a flatter diurnal slope, and was distinct from the typical pattern observed among most participants in this sample.

Aim 2 Hypotheses

Previous studies using the person-centered approach did not appear to have identified diurnal cortisol profiles that are consistently related to age. Aim 2 of the dissertation is to explore the association between chronological age and diurnal cortisol profile membership among a national sample of adults in the United States. The relatively large national sample of adults that provides an opportunity to assess whether there are more than two common patterns of diurnal cortisol, and whether these patterns are related to age. Analogous to exposure to stressors, aging appears to be associated with a disruption of the negative feedback mechanism that enables the HPA-axis to return to homeostasis. Above-reviewed studies suggest that age may be related to higher overall cortisol levels, and flatter cortisol awakening response and diurnal slope. Therefore, I hypothesized that older age would be associated with a greater likelihood of membership in the "high-flat" group.

Aim 3: Age and Stressor Differences in Diurnal Cortisol Profiles

According to the life-span developmental perspective, life experiences accumulate to produce health consequences at each stage of development (for review, see Almeida, Piazza, Stawski, & Klein, 2011). Recent reviews have proposed that although age is statistically associated with typical declines often experienced by the aging body, age may simply be a marker for total accumulated stress-related processes (e.g., Almeida et al., 2011; Epel, 2009;

McEwen, 1998; Piazza, Almeida, Dmitrieva, & Klein, 2010). Thus, the declines attributed to aging may be partially or entirely manifestations of the physiological wear and tear–a consequence of stressful experiences. Decades earlier, Selye speculated that rest and sleep can provide restorative functions, but exposure to stressors, leaves "indelible scars" (1976, p. 429). He wrote, "That is why it [stress] can act as a common denominator of all of the biologic changes which go on in the body; it is a kind of 'speedometer of life'" (1956, p. 274).

One heuristic for understanding the mechanism of stressor accumulation and the consequent physiological burden is allostatic load (Sterling & Eyer, 1988). Whereas allostasis is defined as the achievement of stability following a stressor through modification of cell structure and function, allostatic load refers to the accumulated wear and tear that results from continual accommodation of physiological systems in response to stressors (McEwen, 2001; McEwen & Seeman, 1999). Thus, allostasis is presumed to be adaptive in the short-term, but repeated stressor exposure requiring continued achievement of stability can wear down bodily systems due to constant activity (McEwen, 1998). The allostatic load model is developmental in nature, as it underscores how heterogeneity in stressful contexts produces heterogeneity in rates of aging across individuals. Indeed, studies have shown that greater allostatic load is associated with older age, as well as greater risk of cognitive and physiological declines (e.g., Seeman et al., 1997). Thus, one additional metric of aging may be the accumulation of stressors, such that chronological age may simply be a surrogate marker for increasing accumulation of allostatic load in response to stressful life experiences.

The Strength and Vulnerability Integration model (SAVI; Charles, 2010; Charles & Piazza, 2009) provides further elaboration on physiological vulnerabilities, as well as psychological well-being, associated with aging. The SAVI posits that although older age is

linked to better skills in avoiding or minimizing exposure to negative emotions and increased strengths in emotion regulation, aging is inevitably characterized by losses in the domain of physiological regulation. According to this model, the fundamental age-related physiological vulnerability is a difficulty in returning to physiological homeostasis following a stressful event. This age-related reduced physiological flexibility in response to stressors makes an encounter with a stressful experience more physiologically costly for an older adult, than for a younger adult (Charles, 2010). Compared to the response of a younger adult, an older person's experience with stressors would be characterized by greater physiological activation and prolonged recovery. One key component of the SAVI model is that the age-associated increase in physiological vulnerability to stressors is particularly evident under conditions of persistent or inescapable chronic stressors (Charles, 2010). The current study proposes to examine whether the experience of different types of stressors plays a role in the association between age and one marker of physiological flexibility proposed by Charles (2010)–diurnal cortisol regulation.

Previous work provides empirical evidence that stressors play an important role in accelerating individual markers of aging. For example, several studies have illustrated that stressors increase the rate of telomere shortening (e.g., Epel et al., 2004; von Zglinicki, 2002, 2003). The hormonal cascade may be one mechanism driving stress-induced physiological burdens (e.g., Epel, 2009; Sapolsky et al., 1986). In her review of cortisol as one of the biological pathways whereby stress accelerates aging on a cellular and systems levels, Epel (2009) writes that adaptive allostasis is exhibited by an appropriately robust response to a stressor, followed by a rapid return to homeostasis. In contrast, increasing age, as well as chronic stressors, cause a decline in an ability to regulate the HPA-axis. As under conditions of chronic stress, aging is related to an increased need to adapt to stressful environmental events, resulting in an

accumulation of allostatic load. As discussed in Aim 2, aging may associated with higher baseline levels of cortisol, an exaggerated initial stressor response, and an inability to return to baseline rapidly according to Epel (2009). Furthermore, she posits that the experience of chronic stressors may lead to an impaired return to baseline, similar to the effect of aging, but may be associated with higher or lower cortisol levels, depending on stressor type.

Stressors and the Rate of Health Declines

A large body of work corroborates a direct link between stressor experience and health. However, a relatively small number of studies have examined the effect of stressors on the rate of health declines, and much of this research has focused on investigating the role of socioeconomic inequalities in exacerbating the effects of age on health. Several recent studies have demonstrated a link between stressful and traumatic experiences and the rate of age-related declines across different types of physiological functioning. The following section reviews these intriguing findings.

The experience of stress is associated with poorer health, and this appears to be true for health effects of life events (for review, see Tosevski & Milovancevic, 2006), chronic stressors (for review, see Juster, McEwen, & Lupien, 2010), and daily stressors (for review, see Almeida, 2005). Moreover, stressors appear to modulate the rate of age-related health declines across several levels of physical functioning, including genetic, as well as cardiovascular and immune system functioning.

Cherkas and colleagues (Cherkas et al. 2006) have found that when the length of telomeres among adult female twins are compared, the twin occupying lower socioeconomic status tends to exhibit shorter telomere length. In another prominent study, Epel and colleagues (Epel et al., 2004) found that greater perceived stress among women is associated with shorter

telomere length. They also found that even after controlling for age, greater years of caregiving for a child with a chronic illness is associated with shorter telomere length and lower telomerase activity. Using a community-based sample, Geronimus and colleagues (Geronimus et al., 2010) illustrated that telomeres are shorter among middle-aged black women, than among same-aged white women. In fact, the authors calculated that black women were, on average, 7.5 years older than white women. It is critically important that this ethnic difference in telomere length was no longer significant after accounting for the women's perceived stress and poverty status.

In addition to their effects on a genetic level, stressors also appear to be directly associated with greater age-related disadvantages in physical health. Following their meta-analysis, Segerstrom and Miller (2004) had concluded that when compared to younger adults, older adults experience greater stress-induced impairment in immune system functioning. For example, the immune response to an influenza vaccine is less robust among caregivers than among non-caregivers, and this disparity increases with caregiver age (Kiecolt-Glaser et al., 1996).

An additional way to investigate the effect of stress on rate of aging is to assess the effect of chronic stressors on cumulative biological burden, or allostatic load. Studies investigating socioeconomic and ethnic differences have found a consistent positive association of these factors with allostatic load among a range of samples, including those of the MacArthur Studies of Successful Aging (Seeman, McEwen, Rowe, & Singer, 2001), the Normative Aging Study (Kubzansky, Kawachi, & Sparrow, 1999), and the US National Health and Nutrition Examination Survey (Crimmins et al., 2009; Seeman et al., 2008). One study demonstrated that a particular type of stressor, high job demands, exacerbates this well-studied relation between age and allostatic load (Schnorpfeil et al., 2003). There is a strong positive relationship between job

demands and allostatic load among employees over the age of 45 years old, but no significant effect among employees under the age of 30 years old.

Stressors and the Rate of Aging of Diurnal Cortisol

A recent meta-analysis of 107 independent studies of diurnal cortisol regulation in light of chronic stressors and traumas has underscored the importance of temporal issues related to the stressor-cortisol link, and highlighted a need for research to investigate developmental issues in the relation between stressors and diurnal cortisol (Miller et al., 2007).

The results of the meta-analysis suggest that in general, exposure to stressors is associated with a lower morning cortisol, higher afternoon/evening cortisol, and a flatter overall diurnal rhythm. However, cortisol regulation also depends on the time since stressor onset. The HPA-axis is hyperactivated immediately following a stressor, but assumes a hypocortisolemic state after some passage of time, as evidenced by a reduction in morning levels over time. Participants still undergoing a stressor exhibit higher morning level and higher afternoon/evening cortisol levels. As time since stressor onset increased, morning cortisol decreased, but afternoon/evening cortisol levels remained high.

As reviewed above, there are several high quality studies suggesting that stressors may accelerate age-associated health declines, when health is indexed by biomarkers of immune and genetic functioning (e.g., Epel et al., 2004; Kiecolt-Glaser et al., 1996). In contrast to this evidence, data on the role of stressors in aging of the HPA-axis is less well-researched and less conclusive. Moreover, not all studies support that stressor exposure accelerates age-related changes in diurnal cortisol (e.g., Rohleder et al., 2007). Additional studies are required to reach a more definitive conclusion on the relation between stressors, age, and diurnal cortisol.

However, there is some evidence to suggest that certain factors modulate the relation between age and diurnal cortisol. One longitudinal study examining total plasma cortisol and cognitive function among older adults, found heterogeneity in cortisol changes over time, illustrating that not all participants exhibited an increase in cortisol over the 3-to-6 year study period (Lupien, Lecours, Schwartz, & Sharma, 1996; Lupien et al., 2005). The subset of participants with increasing cortisol levels over time also demonstrated disproportionate declines in cognition.

Another study found that when compared to their non-frail counterparts, 80 to 90 year-old participants who experience of the condition of frailty–also a condition associated with stressors (e.g., von Kanel et al., 2006)–appear to exhibit accelerated age-related diurnal cortisol changes (Varadhan et al., 2008). Specifically, greater frailty burden among these participants is related to higher evening salivary cortisol levels, higher total cortisol levels, and less robust diurnal salivary cortisol declines. This study should be interpreted with caution, however, as diurnal cortisol has independent links with frailty and other physical health conditions.

One study found that distressed men (i.e., those with severe depressive symptoms) show a stronger coupling between age and total urinary cortisol levels (Jacobs et al., 1984). It is remarkable that age was not related to higher total cortisol level among adults exhibiting relatively little distress in this study. These findings suggest that process that may be related to stressors and distress may partially determine differences in diurnal cortisol. It is important to keep in mind that major depression and depressive symptoms have independent links with diurnal cortisol, and the results of this study need to be interpreted with caution.

A comparison of high- and low-stress periods among female teachers provide more solid evidence for the hypothesis that stressors moderating the association between age and early-

morning cortisol level at work (Ritvanen, Louhevaara, Helin, Väisänen, & Hänninen, 2006). Low-stress periods among these women corresponded to low early-morning cortisol at work, and high-stress periods corresponded to high early-morning cortisol at work, but only among younger teachers. In contrast, older teachers exhibited high cortisol level during the early-morning work hours, regardless of stressor period. Data on autonomic nervous system functioning further corroborated that unlike their younger counterparts, older teachers did not experience a drop in heart rate during low-stress periods, and did not exhibit a decrease in blood pressure in the evening.

Another study examined a component of Aim 3 on data that were used for the current dissertation analyses. This study showed that a woman's age moderates the relation between changes in negative family-to-work spillover and her level of evening cortisol (Dmitrieva, Charles, & Almeida, 2010). Older women exhibit higher bedtime cortisol level in light of a 9-year increase in negative family-to-work spillover. This increase in negative family-to-work spillover is not associated with evening cortisol level among younger women. Moreover, this study did not show a similar interaction between age and negative family-to-work spillover on cortisol among men. This gender difference may indicate that heightened arousal produced by increasing negative family-to-work spillover may make it particularly challenging for older working women to disengage from stressors at the end of the day. This finding complements others, which suggest that stressors originating from the family domain are more psychologically distressing to women than to men (e.g., Almeida & Kessler, 1998). An important next step would be to examine age differences across a more global indicator of chronic stress.

Aim 3 Hypotheses and Research Questions

An important restriction in this review is that a direct comparison of findings from above-noted research is difficult because of differences in cortisol media (e.g., cortisol assessed from urine vs. plasma vs. saliva), operationalizations of stress (e.g., psychological distress vs. negative family-to-work spillover), participant samples (i.e., differences in age and gender compositions), and operationalizations of the diurnal cortisol construct (e.g., total cortisol output vs. diurnal slope). The third objective of the current dissertation is to integrate and develop previous findings by examining the degree to which the experience of stressors appears to accelerate cross-sectional age differences in diurnal salivary cortisol. In testing this moderation, the analyses distinguish between the direct effects of different forms of stressors (i.e., life events, chronic stressors, daily stressors).

Very few findings were available to guide directional hypotheses for this aim, particularly in distinguishing between interaction effects of different forms of stressors. In general, I hypothesized that greater exposure to stressors would be associated with a reduced likelihood of exhibiting a "typical" pattern of diurnal cortisol. Conversely, I hypothesized that higher exposure to stressors among younger individuals would be associated with a greater probability of exhibiting a "high-flat" profile, a pattern that is typically associated with older age.

The broader research questions also explored the distinct role of each stressor form on the link between age and diurnal cortisol profile membership. Guided by previous studies on the topic (e.g., Ritvanen et al., 2006), I suspected that higher chronic stress would be associated with a stronger coupling between age and membership in the "high-flat" profile. Previous work found that traumatic events are associated with the "low-flat" profile of diurnal cortisol (e.g., Yehuda

et al., 1995). I therefore conjectured that a higher life event burden would make it more likely that older individuals exhibit a "low-flat," rather than a "typical," or a "high-flat" profile. Daily stressors have been linked with higher overall cortisol output (Stawski et al., 2011) and a flatter diurnal slope (Seltzer et al., 2010) – a profile also associated with older age. I proposed that a greater daily stressor load would further increase age-related risk of exhibiting a "high-flat" diurnal cortisol profile.

The Current Dissertation

The key overarching aim of the current dissertation was to examine the moderating role of stressors on the relation between age and diurnal cortisol. Cortisol is a primary marker of HPA-axis activation that has also been associated with a number of health outcomes, and has been hypothesized to be one of the biological mechanisms linking environmental stressors and age-related health declines. Although cortisol is only one indicator of physiological activation, it is important to increase scientific understanding of the effects of stress and age on its diurnal rhythm.

Specifically, the aims of this dissertation were three-fold: 1) to identify person-centered patterns of diurnal cortisol using a national sample of U.S. adults in midlife, 2) to examine age-associated differences in diurnal cortisol patterns, and 3) to explore of whether and how three different forms of stressful experiences differentially predict the relation between age and diurnal cortisol patterns.

Aim 1

This dissertation's first aim was to address a limitation in the cortisol literature: a paucity of studies exploring latent profiles of diurnal cortisol. The first aim was to identify person-centered patterns of diurnal cortisol using data from the National Study of Daily Experiences

(NSDE) project. First, these patterns were estimated using GMM, based on diurnal cortisol values collected over up to four consecutive days.

The execution of this aim provided an opportunity for an investigation of basal diurnal cortisol that was heretofore unprecedented in its reliability and generalizability of results, and may provide generative directions to other researchers who are interested in examining diurnal cortisol. As previously discussed in the section titled *Aim 1 Hypotheses*, I expected to observe at least three diurnal cortisol groups in these data: "typical," "low-flat" and "high-flat" profiles.

Aim 2

The second aim of the dissertation was to investigate the association between chronological age and diurnal cortisol profile membership. Current literature examining age and diurnal cortisol shows mixed results. The NSDE sample consists of a large number of participants of a wide age range, providing an opportunity to investigate the research question among a sample of respondents that is more representative and utilizes a greater number of cortisol collection days than those of previously published studies. With guidance from previous research, I expected that older adults would be more likely to exhibit a "high-flat" pattern of diurnal cortisol.

Aim 3

In contrast to research on other biological indicators (e.g., telomere length), the evidence on the role of stressors in the aging of diurnal cortisol is less well-researched and less conclusive. The third aim of this dissertation was to test whether greater exposure to life events, chronic stressors, and daily stressors exacerbate the effect of age on diurnal cortisol. I hypothesized that older individuals exposed to more stressors would be less likely to show the "typical" pattern of

diurnal cortisol. I hypothesized that younger adults experiencing greater stressor burden would be more likely to exhibit a “high-flat” cortisol pattern.

CHAPTER 2: METHOD

The opening of the current chapter is devoted to describing study procedures and sample, including the logic supporting selection of participants for the analytic dataset. The chapter closes with a description of measures, and plans of analysis for each of the three proposed aims.

Procedure

National Survey of Midlife in the United States (MIDUS)

The sample consisted of respondents participating in the second wave of the National Study of Daily Experiences, a daily diary component that is a part of the MIDUS. The MacArthur Midlife Research Network carried out the first wave of the MIDUS–a national survey of non-institutionalized, English-speaking adults of the contiguous United States. Participants were recruited through working telephone banks and administered a 30-minute telephone interview. Following completion of the interview, respondents were invited to complete a two-part mail-in self-administered paper-and-pencil questionnaire. Both the telephone and the mail-in surveys assessed behavioral, psychological and social factors (e.g., personality, coping, stressful life events, features of work and family functioning, caregiving), as well as facets of health and well-being (e.g., physical functioning, chronic conditions, depressive symptoms, satisfaction with life). These baseline data collection efforts spanned from 1995 to 1996.

Baseline data collection during the second wave of the MIDUS was supported by the National Institute on Aging and occurred between 2004 and 2006. The interval between the first and second waves of data collection ranged from 7.8 to 10.4 years, with an average interval of approximately 9 years. Similar to the baseline procedure, upon re-contact of MIDUS respondents, interviewers first administered a telephone interview, and mailed a more extensive self-administered questionnaire. After adjusting for mortality, the response and completion rate

for the telephone survey was 75%. In addition to carrying out the study protocol on the longitudinal sample of participants, the MIDUS team also recruited a group of additional respondents in order to increase the ethnic diversity of the sample: a city-specific oversample of African Americans living in Milwaukee, WI. For further detail on recruitment procedure and response rates of the MIDUS sample please see Brim, Ryff and Kessler (2004) and Radler and Ryff (2010).

The National Study of Daily Experiences (NSDE)

The NSDE is a daily diary satellite study–one of the in-depth studies–conducted on a subsample of participants from both waves of the MIDUS study. The purpose of the NSDE was to examine the day-to-day lives of participants, particularly their daily stressful experiences. Approximately 90 days after completion of the second wave of the MIDUS, respondents were invited to participate in the second wave of the NSDE. Data collection efforts began during July 2004 and ended in April 2009. The average time interval between completion of the phone interview from the second wave of MIDUS baseline data collection and completion of the NSDE protocol was 1.9 years, and ranged between 87 days to 4.6 years, with 60.4% of participants completing the NSDE protocol within 2 years of the baseline phone interview.

NSDE respondents completed eight consecutive evening telephone interviews regarding their experiences during the previous day, including questions on daily stressors, positive events, sleep duration, daily health symptoms, psychological distress, and time use. The interviews were conducted by trained interviewers from the Pennsylvania State University's Survey Research Center, during a convenient time, as indicated by the participant, with the computer-aided telephone interview system (CATI). The CATI consists of a keypunch data entry and skip patterns to increase interview efficiency. On the final day of data collection, each participant also

responded to several questions regarding the previous week's experiences overall. To account for seasonal variation in daily experiences, data collection was spread throughout the year, and occurred in separate "flights," each one consisting of approximately 20 respondents.

Participants also collected saliva samples during interview days 2 through 5 of the study protocol. As part of recruitment, respondents received a Home Saliva Collection Kit one week prior to their initial phone call. Sixteen numbered and color-coded salivettes (Sarstedt) were included in the collection kit, each containing a small absorbent wad, about 3/4 of an inch long, an instruction sheet, and a paper-pencil log where participants were to note the date and time of saliva collection. Saliva samples were collected at waking (before getting out of bed), 30 minutes after getting out of bed, before lunch, and at immediately prior to bedtime. Participants were instructed to collect samples before eating, drinking, or brushing their teeth, and were asked not to consume any caffeinated products (e.g., coffee, soda) before collecting samples. When all 16 tubes were ready to be sent, each participant used a pre-addressed, pre-paid courier package for return mailing. The enclosed salivettes were shipped to the MIDUS Biological Core at the University of Wisconsin.

Participants

The sample for the current dissertation consisted of respondents who participated in saliva collection of the second wave of the NSDE. In addition to the measures administered as part of the NSDE Wave 2 daily diary protocol, some of the measures were administered during MIDUS Wave 2 baseline measures.

MIDUS and NSDE Participants

The original MIDUS sample (N=7,108) consisted of four subsamples: 1) a national random digit dialing (RDD) sample (n=3,487), 2) oversamples from five metropolitan areas in

the U.S. (i.e., Atlanta, Boston, Chicago, Phoenix, and San Francisco; *n*=757), 3) a sample of siblings of individuals from the RDD sample (*n*=950), and 4) a national RDD sample of twin pairs (*n*=1,914).

The second wave of the MIDUS (*N*=5,555) was comprised of 1) an RDD sample (*n*=2257), 2) oversamples from five metropolitan areas in the U.S. (*n*=489), 3) a sample of siblings of individuals from the RDD sample (*n*=733), 4) a national RDD sample of twin pairs (*n*=1,484), and 5) an oversample of African Americans living in Milwaukee, WI (*n*=592). Participants from the first four samples of the second wave were longitudinal, whereas the African American sample from Milwaukee was added for the first time at Wave 2.

The second wave of the NSDE consisted of a subsample of MIDUS Wave 2 participants. This total number of NSDE participants (*N*=2,022) was comprised of 1) an RDD sample (*n*=1,079), 2) oversamples from five metropolitan areas in the U.S. (*n*=62), 3) a sample of siblings of individuals from the RDD sample (*n*=185), 4) a national RDD sample of twin pairs (*n*=516), and an oversample of African Americans living in Milwaukee (*n*=180). See Table 2.1 for a comparison of demographic characteristics among MIDUS Wave 2 and NSDE Wave 2 participants. Approximately 94% of participants had completed at least six out of a possible eight interview days, whereas 88% and 69% of the respondents completed seven and eight interview days, respectively. Out of a possible 16,176 daily diary days, the participants competed 14,912 days, yielding a retention rate of 92%.

The majority of respondents participated in saliva collection (*n*=1,736, 86% of total NSDE Wave 2 sample). Participants taking part in saliva collection consisted of 1) an RDD sample (*n*=934), 2) oversamples from five metropolitan areas in the U.S. (*n*=50), 3) siblings of individuals from the RDD sample (*n*=175), 4) a national RDD sample of twin pairs (*n*=448), and

an oversample of African Americans living in Milwaukee (*n*=129). Among the total sample of 1,736 participants, 1,496 participants (86% of sample) described their primary racial origin as White, and 166 participants (nearly 10% of sample) reported their primary racial origin as Black/African American. The remainder of the sample reported their primary racial origins as Native American/Alaska Native/Aleutian Islander/Eskimo (24 participants, 1%), Asian (5 participants, <1%), and other (40 participants, 2%). Nearly one-third of saliva participants had at most graduated from high school or received a GED (30%), nearly one-third obtained some college experience or graduated with an Associate's degree or equivalent (30%), with the remainder of participants reporting receiving a Bachelor's degree (20%), or some graduate school or an advanced degree (19%).

Selection of participants for the analytic sample. As stated above, saliva samples were collected during four days of the study period: at waking (before getting out of bed), 30 minutes after getting out of bed, before lunch, and immediately prior to bedtime. There was one initial exclusion procedure at the level of the discreet value of each saliva level: any sample with cortisol level above 60 nmol/l was recoded into a missing value. This was decided in keeping with previous work showing the importance of excluding extreme cortisol values in this sample (Almeida, Piazza, & Stawski, 2009), as well as other samples (Kumari et al., 2010). Participants with such high values of cortisol may represent a clinical subgroup or subgroups, and appropriate exploration of the nature diurnal cortisol profiles among these respondents would require diagnostic procedures and recruitment of participants that fall outside of the scope of this dissertation.

Previous research indicates that the timing of collection, daily activities, and other factors are critical to obtaining high quality cortisol data. Following trimming of extremely high cortisol

values at the sample level, several procedures were followed to identify days on which a timing of sample collection or a change in cortisol level may have been drawn from a population that lies outside the scope of this dissertation (e.g., non-compliant participants, shift-workers). Due to the focus of this dissertation on identifying typical cortisol patterns, flagged days indicating that a participant did not appear to observe the saliva collection protocol or followed a non-typical sleep schedule, were excluded from the analytic dataset.

Construction of flags identifying days of atypical saliva collection. Diurnal rhythm of cortisol typically fluctuates across the day in relation to the timing of one's schedule (e.g., waking level vs. bedtime level; Van Cauter et al., 1996), time of day (0800 vs. 1200; Wust et al., 2000), and according to one's daily activities (e.g., sleeping; Backhaus, Junghanns, & Hohagen, 2004). Days characterized by particularly long or short sleep duration (and therefore particularly short or long waking hours, respectively) are associated with changes in diurnal cortisol, such as an elevated evening level (e.g., Leproult et al., 1996). Following this previous work, days on which participants were awake for over 20 hours or under 12 hours were excluded from analyses. Further, atypical timing of one's sleeping schedule impacts diurnal cortisol, as has been shown among participants observing night- or shift-work schedules (Federenko et al., 2004). Thus, excluded days when participants woke up prior to 0400 or after 1100 hours were also excluded from analyses.

Several flags were constructed to exclude days when participants did not appear to comply with the saliva collection protocol. The cortisol awakening response may not be apparent among participants who delay the collection of the sample associated with diurnal peak of cortisol by more than 1 hour. Due to the central importance of the peak level of cortisol in operationalizing the cortisol awakening response and diurnal slope, all days on which

participants reported collecting the 30-minute after waking sample earlier than 15 or later than 60 minutes after waking were excluded. Further, a significant afternoon or evening rise in cortisol in relation to level observed at 30 minutes after waking (i.e., typically the highest cortisol level of the day), may indicate non-compliance of eating, brushing teeth, or other activities that should be avoided at least 30 minutes prior to sample collection. Therefore, I excluded days on which lunch and dinner sample values increased by more than 10 nmol/l in comparison to 30 minute-post waking value (T. E. Seeman, personal communication, September 8, 2010).

Analytic dataset for identifying profiles of cortisol. Although Survey Research Center interviewers, the cortisol assay team, and the NSDE team made every effort to obtain reliable and valid values for cortisol levels, some participants did not elect to provide all four saliva samples during each of the days of the entire four-day saliva collection period. Two distinguishing features of the current dissertation from much of the previous research on diurnal cortisol were the foci on person-centered patterns of cortisol (i.e., simultaneous modeling of diurnal cortisol profile and level), and an improvement in the degree to which diurnal cortisol profiles are representative of each individual's levels of naturally-occurring cortisol. High-integrity, reliable data are crucial to carrying out these foci and extending the current literature on the topic. Thus, in the interest of identifying diurnal patterns across the entire day, a saliva day was included in the analytic dataset only when participants exhibited valid values on all 4 saliva samples, after exclusion criteria were incorporated into the sample.

Of the total sample of 1,736 saliva participants, 1,622 (93%) provided at least one full day of valid cortisol value data. This subsample constitutes the data analytic database for Aim 1 of the current dissertation: identification of different types of patterns of diurnal cortisol.

The following describes the sample of participants who provided at least one full day of valid cortisol value data. The majority of participants (n=889) were part of the RDD sample, with remaining respondents recruited from the five metropolitan area oversamples (n=45), siblings of individuals from the RDD sample (n=167), an RDD sample of twin pairs (n=420), and African Americans living in Milwaukee (n=101). Among respondents providing at least one day of valid cortisol values, age ranged between 34 and 87 years old (mean age=58 years old), and 56% were female. With regard to ethnic background, 1,417 participants (87%) described their primary racial origin as White, and 137 participants (8%) reported their primary racial origin as Black/African American. The remainder of the sample reported their primary racial origins as either Native American/Alaska Native/Aleutian Islander/Eskimo, Asian or other, with four participants Nearly one-third of saliva participants had at most graduated from high school or received a GED (30%), nearly one-third obtained some college experience or graduated with an Associate's degree or equivalent (30%), with the remainder of participants reporting receiving a Bachelor's deg

Analytic dataset for analyses of stability and variability in diurnal cortisol profiles. As previously discussed, 1,622 out of 1,736 participants (93%) provided at least one full day of valid cortisol value data. Moreover, 1,470 (87%) completed at least two full days, 1,237 (71%) completed at least three full days, and 824 (47%) provided valid cortisol values on all four of the cortisol collection days.

The creation of a sample of participants for analyses of stability and variability of cortisol profiles across days was informed by results of analyses identifying cortisol profiles (i.e., *Aim 1* results). The 3-class solutions provided the best fit across days (see *Results*), and the changes in profile membership across days indicated that whereas the profile parameters did not vary from

day-to-day, there was intraindividual variability in profile membership. Thus, it was important to select respondents who participated in at least three days of cortisol collection, in order to investigate the stability and variability in membership across the three common diurnal cortisol profiles across the study period. Table 2.2 provides a comparison of demographic characteristics among participants from NSDE Wave 2 (*n*=2,022), a subsample providing at least one day of cortisol collection (*n*=1,622), and a group of participants providing at least three days of cortisol data (*n*=1,237).

Measures

Salivary Cortisol

Participants were instructed not to eat, brush teeth, or consume any caffeinated products at least 30 minutes prior to collecting each saliva sample. Following saliva collection, participants used a pre-addressed, paid courier package to ship the salivettes to the MIDUS Biological Core at the University of Wisconsin, where they were stored in an ultracold freezer at -60 ^{o}C. The procedure detailing saliva preparation and assay is included in *Appendix B,* below. Briefly, prior to assays, the salivettes were thawed and centrifuged at 3000 rpm for 5 minutes, yielding a clear fluid with low viscosity. The assays were conducted at the Biological Psychology Laboratory at the Technical University of Dresden. Cortisol concentrations were quantified with a commercially available luminescence immunoassay (IBL, Hamburg, Germany), with intra-assay and inter-assay coefficient of variations below 5% (see previous studies, e.g., Dressendorfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992).

The results of the assay indicated that 26,902 saliva samples (97%) out of the 27,776 possible samples provided reliable cortisol values. Of the remaining samples, 418 samples were missed, 392 samples contained insufficient saliva volume to detect cortisol, 40 samples provided

unreliable cortisol values, and 24 could not be linked to a specific interview day (see Appendix B for further detail). Given the focus on naturally-occurring profiles of cortisol, all analyses examined raw cortisol values.

Control Variables

Prescription and over-the-counter medications taken during the saliva collection period were recorded during the telephone interview on the last day of saliva collection. Typically, these questions are administered on day 5 of the NSDE interview protocol, unless the participant finished saliva collection early (e.g., interview day 4) or late (e.g., interview day 6). Participants endorsed use of seven types of medication with a *yes* or *no* response. Specifically, participants were asked if they used any of the following medications on days they collected saliva: over-the-counter prescription allergy medications (e.g., Benadryl), steroid inhalers (e.g., Advair), other steroid medications (e.g., Prednisone), medications or creams containing cortisone (e.g., Cortaid), birth control pills (e.g., Estratest), and anti-depressant or anti-anxiety medications (e.g., Celexa). Descriptive analyses examining the effect of each medication type on cortisol levels in these data did not provide clear guidance on which particular medications are least and most related to cortisol levels, likely due to a difficulty in disentangling complex pharmacological effects on hormone levels in national study where respondents self-collect saliva samples at home. Thus, a simple binary variable indicating *Any Medication Use* during saliva collection was created in order to account for the effects of medication use on cortisol levels.

NSDE participants reported the number of cigarettes smoked since previous interview (or in the past 24 hours) on every interview day. To account for the effect of cigarette smoking on cortisol, a binary *Any Cigarette Smoking* variable was created to identify all individuals who had smoked at least one cigarette during the eight-day diary protocol. Given the small proportion of

non-Caucasian respondents in the final analytic dataset, a binary variable indicating whether the participant was *Caucasian* was used to account for ethnic background in analyses. No continuous measure of education was available in the MIDUS dataset, thus, a binary *College Degree or More* variable was used to control for education differences across participants. No reliable identifier of menopausal status was available in the MIDUS dataset, but it was possible to construct a binary control variable indicating whether or not a woman had experienced a period in the past year.

Given the varying lag of time between NSDE and MIDUS data collection periods (i.e., 0.3 to 4.6 years), a continuous measure of *Lag (MIDUS to NSDE, yrs)* was created. Finally, the authors of the *Standardized Summary Stress Measure* (Slopen et al., 2010; Lewis, 2010; see below for more information on assessment of chronic stressors) emphasize the importance of controlling for marital/partner status, parenting status, and work status, given the crucial nature of these roles for their measure of stress. Thus, the following binary control variables were used: Currently Married/Partnered, Currently Working, Has 1 or More Children.

Age

Interviewers queried participants regarding their birth dates during the phone interview of the second wave of MIDUS baseline data collection. Participants' birthdates were verified using stringent methodology, including checking against Social Security records, where possible, in order to ensure correct documentation of birthdates for all participants. Age at second wave of MIDUS was computed by subtracting the birth date from phone interview date, and the result was rounded down to a whole number, thereby indicating participants' ages as of their last birthday prior to the phone interview. The final *Age* variable was computed by adding the

number indicating lag between MIDUS and NSDE data collection, as suggested by MIDUS team members (B. T. Radler, personal communication, May 16, 2011).

Stressors

Three standardized global indicators of stress–life events, chronic stressors, and daily stressors–were examined as moderators of the relation between age and diurnal cortisol. To increase readability, Figures 2.1, 2.2, and 2.3 present a graphical representation of how each of the three measures of stress were constructed. Additional analyses indicated that there were modest correlations between the three indicators of stressors, ranging between 0.1 and 0.4.

Life events. Two measures of life events were utilized to create a global *Life Events* measure: *Adult Stress Events* and *Child Stressful Events* (Slopen et al., 2010; Lewis, 2010). These scales consisted of retrospective reports of events and conditions experienced throughout the life-span. The items were administered during the self-administered questionnaire component of the baseline MIDUS Wave 2 measures for all participants except the Milwaukee sample, which provided their reports during the Milwaukee interview component of the study. The two measures were standardized and summed to create a composite indicator of *Life Events.*

The measure of *Adult Stress Events* was a count variable, summing *yes* responses across 22 stressful experiences, including the following: being fired from a job, declaration of bankruptcy, loss of home to fire/flood/natural disaster, being homeless, and experiences of combat, death of a parent, death of child, and detention in jail. The measure of *Child Stressful Events* was a count variable, summing *yes* responses across 10 stressful early-life experiences, including the following: flunking out of school, being sent away from home because you did something wrong, receipt of welfare for a period of six months or more during childhood or adolescence, and moving to a totally new neighborhood or town two or more times during

childhood. The number of total affirmative responses was summed across each measure to comprise and indicators of life events.

Chronic stressors. *Chronic Stressors* were operationalized from the adapted version of the *Standardized Summary Stress Measure,* Lewis, 2010; N. Slopen & D. R. Williams, personal communication, January 3, 2011). *Chronic Stressors* was a standardized global assessment of strain, overloads and inequality across several domains of psychosocial functioning.

Chronic Stressors measure consisted of a combination of several previously validated measures related to chronic stress. A similar approach was previously carried out on all stress-related scales that were administered during baseline data collection in order to compile a *Standardized Summary Stress Measure* (Lewis et al., 2010; Slopen & Williams, personal communication). I employed a similar strategy, but adapted the *Standardized Summary Stress Measure* to assess chronic stressors only, by excluding all scales related to stressful life events, and by excluding scales that were not previously validated in the literature. The combined score consisted of a sum of standardized scores from the following stress measures: *Negative Work-to-Family Spillover* and *Negative Family-to-Work Spillover* (Grzywacz & Marks, 2001), scales evaluating characteristics of job (i.e., *Skill Discretion* (reverse-coded), *Decision Authority* (reverse-coded), *Job Demands*, *Coworker Support* (reverse-coded), *Supervisor Support* (reverse-coded); Karasek & Theorell, 1990), scales assessing perception of inequality (i.e., in *Perceived Inequality in Family, Home, and Work*; Ryff, Magee, Kling, & Wing, 1999), *Discrimination* (Williams, Yu, Jackson, & Anderson, 1997), scales measuring relationship stress (*Family Strain*, *Friend Strain*, *Spouse/Partner Strain Scale*; Whalen, & Lachman, 2000), scale appraising neighborhood stress (*Personal Beliefs on Neighborhood*; Keyes, 1998). These measures were collected as part of the baseline MIDUS self-administered questionnaire.

Daily stressors. Two indicators of daily stressors were standardized and summed to create a global measure of *Daily Stressors*: *Number of Daily Stressors* and *Daily Total Stressor Severity*. During the NSDE protocol, participants were asked to report on their daily experiences using the Daily Inventory of Stressful Events (DISE, Almeida et al., 2002), a semi-structured instrument that assesses a wide array of daily stressors. This inventory was created specifically for assessment of daily stressors, outside of stressor outcomes (e.g., well-being) and other event types (e.g., chronic stressors). The inventory consisted of a series of stem questions asking whether certain types of events (i.e., arguments and avoided arguments at work and at home, discrimination, network stressors, and other stressors) had occurred in the past 24 hours (or since the previous evening's interview), along with a set of guidelines for probing affirmative responses. For example, one of the stem questions queried, "Since we last spoke, have you experienced anything at work that most people would consider stressful?" The aim of the interviewing technique was to acquire a short narrative of each event that includes descriptive information (e.g., duration, timing, and overlap with other events), as well as what was at stake for the respondent. All interviews were tape-recorded, transcribed, and coded for several characteristics including: 1) specific classification (e.g., work overload, argument with spouse, traffic problem), 2) who was involved in event, and 3) subjective severity of stressor.

The total number of stressors on each day was calculated by summing all of the affirmative responses to stressor stem questions on a particular day. In order to obtain a stable depiction of how many daily stressors each participant tends to experience, *Number of Daily Stressors* was operationalized by averaging the total number of daily stressors experienced by the participant across the total number of interview days that were completed by the participant.

Subjective severity of each stressor was assessed on a 4-point scale (i.e., *not at all stressful* to *very stressful*) after the participant endorsed experiencing a particular stressful event. The total burden of stressor severity on any given day was operationalized by summing all stressor severity ratings across each day. In order to obtain a stable depiction of typical total daily severity burden for each participant, *Total Daily Stressor Severity* score was created by averaging the total daily stressor severity scores across the total number of interview days completed by the participant.

Plan of Analyses

Aim 1 Analyses

Analyses were based on data among participants who completed at least one day of saliva collection with valid cortisol values (as discussed in *Analytic Dataset for Identifying Profiles of Cortisol*). In order to identify patterns of diurnal cortisol, Mplus (Version 6; Muthén & Muthén, 2010) was used to conduct the Growth Mixture Modeling approach (GMM; Muthén & Shedden, 1999; for reviews, see Jung & Wickrama, 2008; Muthén, 2004). GMM is a person-centered approach that uses the Structural Equation Modeling framework to incorporate conventional Latent Growth Modeling with Latent Class Growth Analysis (Muthén & Muthén, 2000). This model allows estimation of mean growth curves (e.g., intercepts, slopes) within classes of a heterogeneous population, as well as the individual variation around mean growth curves among participants within each class. Results are based on a latent basis GMM, an approach that estimates the timing of collection parameters as a latent factor in order to estimate coefficients for the growth parameters. Time and slope loadings, in conjunction with means and variances of intercepts and slopes were unconstrained across groups.

Correct classification of participants according to the appropriate pattern was of critical importance, as these group memberships were also used not only to estimate the nature (i.e., growth coefficients) of patterns of cortisol, the probability and proportion of individuals within each group, and within-class variance within each group, but also to carry out Aims 2 and 3 of the dissertation. Procedures relevant to identifying solution with the best classes in GMM (e.g., indices of model fit, theoretical justification), as discussed in Mplus User's Guide (Muthén & Muthén, 2010, Chapter 8), were implemented to assure high confidence in resulting diurnal cortisol profiles. Previous literature utilizing GMM in general (e.g., Muthén, 2004; Muthén & Muthén, 2000), and the latent basis GMM as it applies to salivary cortisol data (i.e., Ram & Grimm, 2009) were also utilized as resources. The outline of these steps is presented below in further detail.

The results of mixture modeling are sensitive to start values (i.e., the number of random sets of starting values) (Hipp & Bauer, 2006), and the number of final optimizations (Jung & Wickrama, 2008), such that low values in these parameters may lead to problems with replication of the solution with the lowest log-likelihood value or with convergence on local, rather than global minima. Previous literature suggests that it is important to increase starting values from the default 10, and to increase the number of final optimizations from the default 2, in order to identify the solution with the highest log-likelihood (Hipp & Bauer, 2006; Jung & Wickrama, 2008). I began with 500 start values and 10 optimizations for low-complexity models (e.g., 1-class) and increased these values for models with higher complexity, or in cases where the log-likelihood values were not replicated. The best log-likelihood value was checked for multiple replications, to increase the likelihood of convergence on the global minima/maxima (Jung & Wickrama, 2008).

Models with up to four profiles were estimated, and the best fitting model was chosen by using several important criteria. One such criterion is the average posterior probability. The model simultaneously assesses participants according to their probability of membership in each profile in reference to each of the other profiles, which is indicated by the average posterior probability of membership to assigned group for each participant. Nagin (1999) suggests that selecting models where average posterior probabilities exceed 0.7, whereas Jung and Wickrama (2008) recommend higher posterior probabilities closer to 1.0, in order to increase the degree of confidence in group assignment and model fit.

An additional critical parameter is the Bayesian information criterion (BIC), which determines the model that best fits the data (i.e., smallest BIC), while simultaneously penalizing for additional number of parameters, ensuring that the most parsimonious model is chosen. In addition to the BIC criterion, the most appropriate solutions for these data were assessed with the Lo-Mendell-Rubin likelihood ratio test (Lo, Mendell, & Rubin, 2001). This test provides a formal likelihood ratio statistic that compares a model with k groups to a model with $k - 1$ groups. Following this, the parametric bootstrapped likelihood ratio test (BLRT) in order to replicate the log-likelihood in repeated bootstrap draws. This test is more computationally intensive, but is the best performing index of model fit (Nylund, Asparouhov, & Muthén, 2007). During the selection of the best model, it was important to make certain that no group is too small, to ensure that no profile resulted from a spurious clustering of data, and to increase the likelihood that the solution will be cross-validated in other samples. The proposed cutoffs for this criterion include groups with less than 1% of participants (Jung & Wickrama, 2008), or a solution that extracted multiple groups with fewer than 5% of participants (Muthén & Muthén, 2000). Finally, the theoretical meaningfulness, similarity across groups, and interpretability of

results was considered in determining the appropriate number of latent groups (Muthén & Muthén, 2000).

Following selection of the appropriate class solutions, group assignments and posterior probabilities of membership were obtained for each individual, exported, and saved. Plots of estimated individual growth trajectories in diurnal cortisol within each group were plotted and investigated. Two strategies were employed to assess patterns of cortisol profiles across the entire study period, in order to carry out Aim 2 and Aim 3 analyses. The first strategy was to average each respondent's average posterior probability of exhibiting each of the cortisol profiles, across the study period. This provided each participant with a continuous average indicator of probability of exhibiting each of the estimated cortisol profiles. The second strategy was to ascertain all types of profiles that each respondent exhibited over the study period. This strategy produced one categorical for each individual, signifying all profiles that he or she exhibited on at least one study day.

Aim 2 Analyses

Completion of Aim 1 analyses produced information regarding posterior probabilities and group membership in cortisol profiles for each respondent. This information was used to carry out Aim 2: the examination of the relation between age during NSDE protocol and cortisol patterns. After accounting for control variables, relations were tested using linear and multinomial logistic regressions in SPSS. As proposed, the group with the largest number of participants was used as a baseline or comparison group in multinomial logistic regressions.

Aim 3 Analyses

Multinomial logistic regressions modeled during Aim 2 analyses were extended to carry out Aim 3: exploration of the role of stressors on the relation between age and diurnal cortisol

patterns. Each of the three constructed measures of stress were examined as moderators. The three interaction terms between standardized age and stressor variables were tested in the model simultaneously.

Table 2.1

Demographic Characteristics: MIDUS II Sample and NSDE II Sample

Characteristic	MIDUS II					NSDE II				
	Total Sample (N = 5,555)					Total Sample (N = 2,022)				
	%	*M*	*SD*	Range	% Missing	%	*M*	*SD*	Range	% Missing
Age (at MIDUS II, yrs.)		55.0	12.5	28-85	< 0.1		56.3	12.2	33-84	0.0
Gender (Female)	54.3				0.0	57.2				
Ethnicity					0.5					0.3
Caucasian	80.0					84.5				
African Am.	14.1					11.3				
Education					0.1					0.2
≤ H.S./GED	35.4					31.1				
Some College/A.A.	30.0					30.4				
Bachelor's Degree	17.9					19.6				
> Bachelor's	16.6					18.8				

Table 2-2

Demographic Characteristics: Samples by Different Level of Cortisol Participation

Characteristic	NSDE Sample (*N* = 2,022)					1+ Cortisol Days (*N* = 1,622)					3+ Cortisol Days (*N* = 1,237)				
	%	*M*	*SD*	Range	% Missing	*%*	*M*	*SD*	Range	% Missing	*%*	*M*	*SD*	Range	% Missing
Age (at NSDE II, yrs.)		58.1	12.1	34.4-86.5	0		58.2	12.0	34.4-86.5	0		58.0	11.9	34.4-84.8	0
Gender (1=*female*)	57.2				0	56.2				0	55.6				0
Ethnicity					0.3					0.2					0.2
Caucasian	84.2					87.4					89.8				
African American	11.3					8.4					6.2				
Education					0.2					0.2					0.2
≤ H.S./GED	31.1					29.8					29.3				
Some College/A.A.	30.4					30.1					28.9				
Bachelor's Degree	19.6					20.4					21.2				
> Bachelor's	18.7					19.5					20.5				
Currently Employed	66.8				0.3	67.4				0.2	68.0				0.2
Respondent has 1+ child	88.0				0	87.9				0	87.4				0
Married/Partnered	71.8				0	73.7				0	75.0				0
Lag MIDUS to NSDE (yrs.)		1.9	1.1	0.2-4.6	0		1.8	1.1	0.3-4.6	0		1.8	1.1	0.3-4.6	0

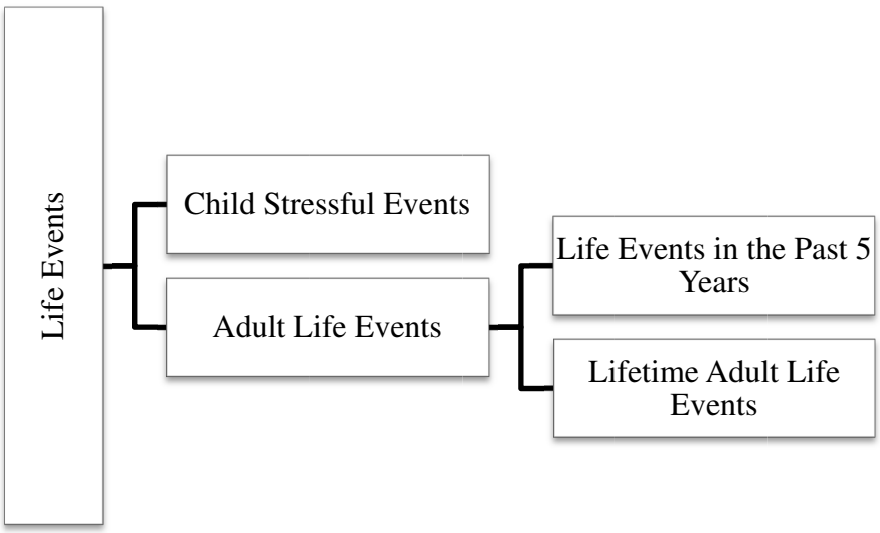

Figure 2.1. Descriptive Figure Charting Standardized Global Measure of Life Events.

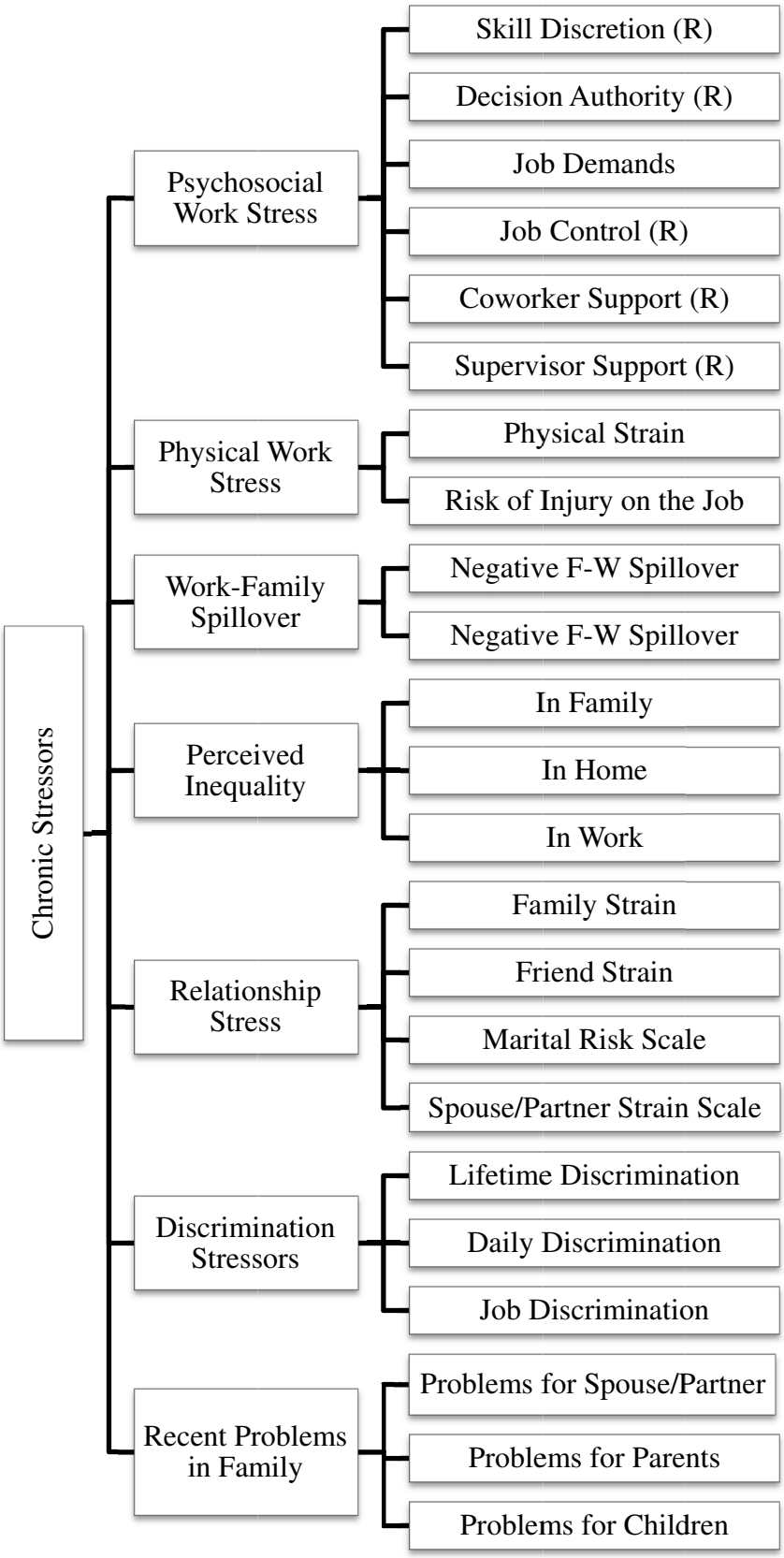

Figure 2.2. Descriptive Figure Charting Standardized Global Measure of Chronic Stressors.

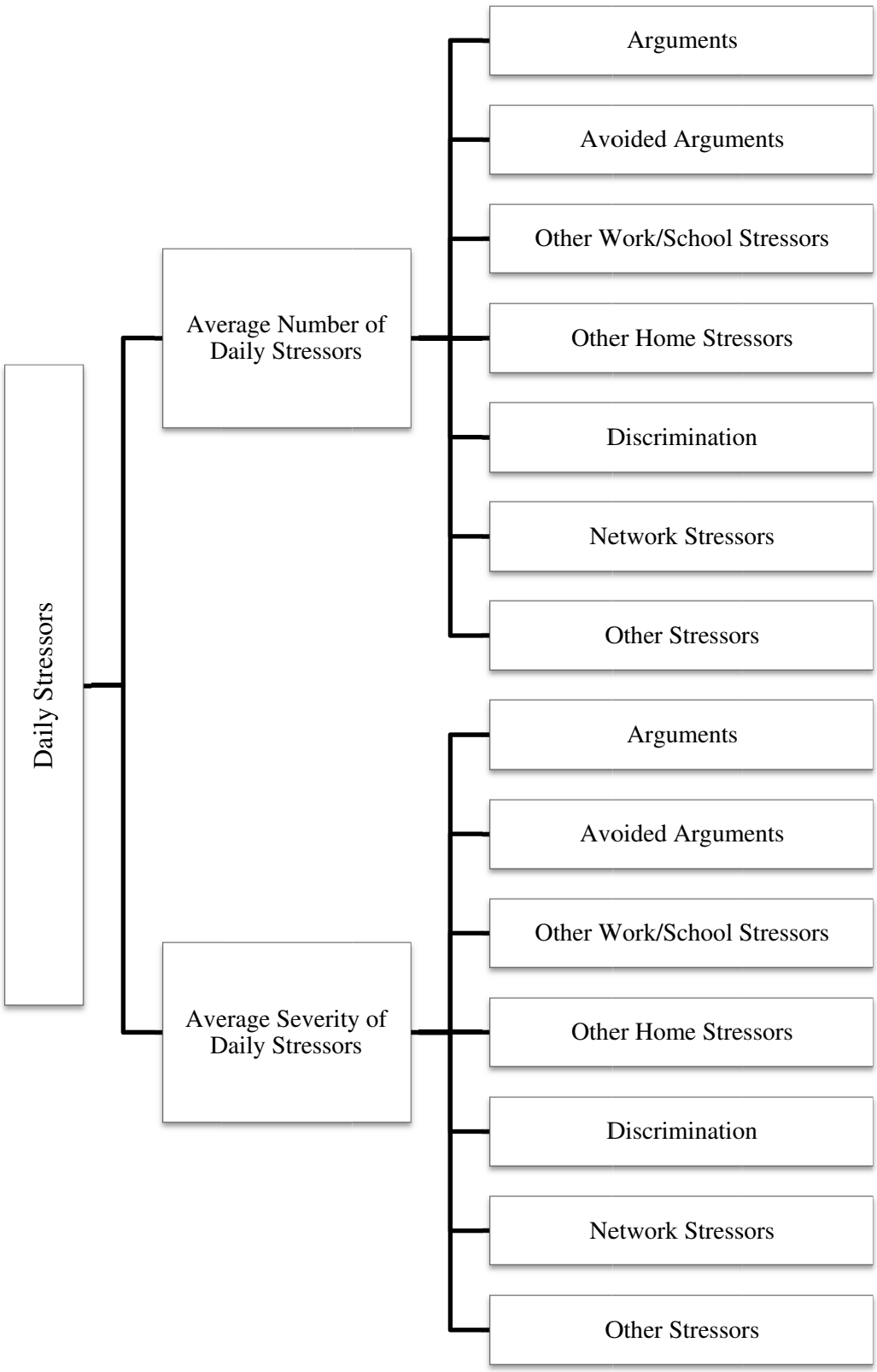

Figure 2.3. Descriptive Figure Charting Standardized Global Measure of Daily Stressors.

CHAPTER 3: RESULTS

The current chapter provides a detailed review of results of proposed analyses, according to the order of aims proposed in the *Introduction* and *Method*.

Aim 1: Identification of Diurnal Cortisol Profiles

Identification and Selection of Cortisol Profiles

The first aim of this dissertation was to identify person-centered profiles of diurnal cortisol. I hypothesized that the best fitting models would identify at least three diurnal cortisol groups in the NSDE data: "typical," "low-flat" and "high-flat" profiles. As described in the *Plan of Analyses*, GMM with latent time basis for models estimating 1- through 4-class solutions were performed. The results of these analyses, including model fit indexes, and parameter estimates, are presented in Tables 3.2 through 3.9, and Figures 3.2 through 3.5.

Following selection of participants and saliva collection days deemed appropriate for this investigation (as described in *Method*), Table 3.1 was constructed in order to provide average values and other descriptive information on cortisol values. Depending on day of study, 1,004 to 1,465 participants provided all four valid cortisol values across the day. Average cortisol values ranged between 14.84-15.03 nmol/l, 21.07-21.57 nmol/l, 6.66-7.02 nmol/l, and 2.79-3.12 nmol/l, for awakening, 30min after waking, before lunch, and before bedtime samples, respectively. Figure 3.1 illustrates observed cortisol values across the day, based on 200 randomly-selected respondents participating in the first day of saliva collection. These descriptive results portray that although most participants exhibit the cortisol awakening response and diurnal slope, there is substantial interindividual variability in level and slope of these parameters.

Tables 3.2, 3.3, 3.4 and 3.5 show fit indexes for models estimating 1-4 classes for saliva collection day 1, 2, 3 and 4, respectively. These tables indicate whether the lowest log-likelihood

value of the model was replicated multiple times, and include information that was used to identify the best fitting models (e.g., sample-adjusted BIC values, BLRT *p*-values). For illustrative purposes, Figure 3.2 shows a graphical representation in sample-size-adjusted BIC values across models within each saliva collection day. Tables 3.6 through 3.9 display solutions across models with various numbers of classes specific to each saliva collection day, including estimated class counts and proportions, average posterior probabilities, and parameter estimates. Finally, Figures 3.3 through 3.6 provides a graphical illustration of estimated diurnal cortisol profiles, for saliva collection days 1, 2, 3 and 4, respectively.

Assessments of models following procedure outlined in the section titled *Plan of Analyses*, indicated that models estimating 3-class solutions provided the best fit for modeling diurnal cortisol across each of the saliva collection days. Tables 3.2, 3.3, 3.4 and 3.5 indicate that AIC, BIC, and sample-size adjusted BIC values dropped consistently, as model complexity increased to incorporate three classes. All 3-class solutions exhibited moderately-high entropy levels, ranging between 0.75 and 0.81. Moreover, Tables 3.2, 3.3, 3.4 and 3.5 shows that likelihood ratio tests (i.e., LMR, adjusted LMR and BLRT) supported that the 2-class solutions provided better fit to these data than single-class solutions, and that, in turn, the 3-class solutions provided significantly better fit than the 2-class solutions.

Tables 3.6, 3.7, 3.8 and 3.9 show that across all 4 days of saliva collection, the 3-class solution converged on three profiles with remarkable consistency, as can be seen in proportions of participants within classes across day, average posterior probabilities, and parameter means and variances.[1] Average posterior probabilities were generally high. Across day of study, average posterior probabilities ranged between 0.89 to 0.94, 0.86 to 0.90, and 0.90 to 0.95 for

[1] Model results and profile parameters were also replicated based on a randomly-selected cortisol participation day (results not shown).

Class 1, Class 2 and Class 3, respectively. The estimated proportions of respondents exhibiting a particular cortisol profile were somewhat dependent on study day, such that the proportion of respondents estimated to belong to the Class 1, Class 2 and Class 3 varied from 59 to 72%, 20 to 32%, and 8 to 10%, respectively.

Figures 3.3 through 3.6 provide a graphical display all solutions with replicated lowest log-likelihood values for saliva collection days 1, 2, 3 and 4. These figures demonstrate that across all days of saliva collection, the 3-class solutions consistently revealed a "typical" cortisol profile (i.e., Class 1), characterized by the most robust cortisol awakening response and diurnal slope, an "elevated" cortisol profile (i.e., Class 2), characterized by high morning values coupled with a relatively flat cortisol awakening response and diurnal slope, and a "flat" cortisol profile (i.e., Class 3), characterized by an unpronounced cortisol awakening response and diurnal slope. Estimates showed that approximately two-thirds of participants exhibited the "typical" profile, with approximately one-quarter of participants, and one-tenth of participants exhibiting the "elevated" and "flat" profile, respectively.[2]

Conversely, 4-class solutions displayed less consistent results. The lowest log-likelihood values for 4-class solutions were not replicated on days 1 and 2 of saliva collection, despite increased starting values. This indicates that these solutions may have converged on a local minima, and do not provide reliable estimates. The lowest log-likelihood values of the 4-class solutions were replicated within days 3 and 4 of saliva collection, however the likelihood ratio tests (i.e., LMR, adjusted LMR and BLRT) confirmed that the 4-class solution provided a significantly better fit over the 3-class solution only in the case of the fourth day of saliva

[2] Model results and profile parameters were also replicated when exploratory analyses were run separately for men and women; showing that the 3-class model, with similar cortisol profiles to those presented here, fit data best within both genders.

collection. This 4-class solution extracted two classes with fewer than 10% of cases, indicating that these smaller groups may have resulted by chance, and may provide little theoretical interest.

Stability and Variability in Cortisol Profiles across Day of Study

The next step following the selection of 3-class models was to use two approaches in order to examine between-person stability and variability in cortisol profiles across saliva collection days. Descriptive associations with variables of interest, prior to accounting for control variables, are also presented in this section.

Person-centered average posterior probabilities across study days. In the first approach, posterior probabilities of displaying a "typical" profile on any given saliva collection day–ranging from 0 to 1– were exported and saved as four discrete variables: one per each day of study. Following this, posterior probabilities were averaged across days in order to create a between-person indicator of each participant's average posterior probability of exhibiting a "typical" profile. A similar procedure was conducted to derive each participant's average posterior probabilities of exhibiting "elevated" and "flat" profiles.

Table 3.10 provides descriptive associations between cortisol profiles and several self-reported characteristics of interest, among participants providing at least one day of valid cortisol values. Significant relations among these cortisol outcomes further serve as a validity check, underscoring the importance of this indicator of diurnal cortisol profiles. Column one of Table 3.10 demonstrates that a greater person-centered average posterior probability of exhibiting a "typical" profile was associated with younger age ($p<.001$), being female ($p<.001$), being Caucasian ($p<.01$), not being African American ($p<.001$), working for pay ($p<.001$), not smoking cigarettes ($p<.001$), better self-rated global health ($p<.01$), and a higher score on a global indicator of daily stressors ($p<.01$). Column two shows evidence that a greater person-centered

average posterior probability of exhibiting an "elevated" profile was associated with older age ($p<.001$), being African American ($p<.01$), not being currently employed ($p<.001$), and a greater likelihood of smoking cigarettes during the NSDE saliva collection period ($p<.05$). Column 3 illustrates that a greater person-centered average posterior probability of exhibiting a "flat" profile was associated with older age ($p<.001$), lower self-rated global health ($p<.001$), and a lower score on a global indicator of daily stressors ($p<.05$). Further, this outcome was related to a greater likelihood of being African American ($p<.05$), and smoking cigarettes ($p<.001$), and a lower likelihood of being female ($p<.001$), being Caucasian ($p<.01$) and being currently employed ($p<.01$).

Person-centered combinations of cortisol profiles across study days. The second approach to examining stability and variability in diurnal cortisol over the full saliva collection period consisted of identifying all combinations of diurnal cortisol profiles exhibited by individual participants. As shown in rows one and two of Table 3.11, the largest proportion of respondents (43.2%) exhibited the "typical" cortisol pattern across the entire study period. Other stable profiles were relatively uncommon, such that only 0.6% of respondents always exhibited a "flat" profile, and 3.0% of respondents always exhibited an "elevated" profile.

In this sample, the majority of the respondents who did not always experience a "typical" profile, tended to exhibit variability in diurnal cortisol profiles – some combination of more than one cortisol profile across this study period. The largest group of such participants (32.9%) experienced a "flat and typical" cortisol pattern. A number of participants exhibited all three cortisol profiles across the study (i.e., 8.1%), whereas 8.3% showed an "elevated" and a "typical" profile during the study. Finally, 49 participants (4.0%) never exhibited a "typical" profile, showing both an "elevated" and a "typical" profile during the study.

Tables 3.11 and 3.12 depict the relations between self-reported variables of interest and various types of cortisol patterns across the study period. Table 3.11 shows correlational relations between individuals always exhibiting a "typical" profile with those showing another combination of patterns throughout the study. Older age, minority status, and poorer health outcomes tended to be more likely among individuals exhibiting an "elevated and flat" pattern, and, to a slightly lesser extent, within the "always elevated" pattern. There was some indication that poorer self-rated global health and poorer health behaviors can be observed among the "flat and typical" pattern and among the "elevated, flat and typical" pattern. Further, indicators of stress were positively associated with the "always typical" pattern.

Table 3.12 presents a test mean of differences between person-centered cortisol patterns across self-reported variables of interest. The omnibus ANOVA test showed cortisol patterns predicted participant age (F=6.09, p<.001), self-reported global health (F=2.28, p<.05), and average number of daily stressors (F=2.41, p<.05). LSD post-hoc tests indicated that the youngest participants exhibited the "always typical" pattern, whereas the oldest participants exhibited the "always elevated" and "elevated and flat" patterns. Participants exhibiting the "always typical" and "elevated and typical" patterns exhibited the highest self-rated global health, whereas participants within "elevated and flat" and "flat and typical" patterns reported the poorest health. Respondents showing the "flat and typical" pattern reported the highest number of daily stressors, whereas the fewest daily stressors were observed among "elevated and flat" and "always elevated" patterns.

Aim 2: Age Differences in Cortisol Profiles

In carrying out Aim 2, the goal was to examine age differences in diurnal cortisol profiles, after accounting for relevant control variables, among respondents who provided at least

three days of valid cortisol data. According to hypotheses, older age should be associated with a lower likelihood of exhibiting a "typical" profile, and a greater likelihood of exhibiting a "high-flat" profile. Results from the first set of analyses, as shown in Tables 3.13 through 3.15, present the effects of age on person-centered average posterior probabilities of exhibiting "typical," "elevated," and "flat" cortisol profiles. Table 3.16 demonstrates findings from the second approach to analyzing cortisol patterns: the effect of age on a probability of exhibiting a particular diurnal cortisol profile across the entire saliva collection period.

First, three hierarchical linear regression analyses were used to examine whether age predicts one's average posterior probabilities of exhibiting "typical," "elevated," and "flat" profiles. Model 2 of Table 3.13 shows that after controlling for gender, ethnicity, cigarette smoking and use of any medications during the NSDE data collection, education, marital/partner status, employment status, and number of children during MIDUS data collection, as well as the lag in timing between NSDE and MIDUS data collections, age was related to a lower average posterior probability of exhibiting a typical profile. Each additional year of age on the part of the participant decreased the average posterior probability of exhibiting a "typical" profile by 0.004 units ($p<.001$). Model 2 of Table 3.14 further indicates that after adjusting for the relevant control variables, each additional year of age was related to a higher average posterior probability of exhibiting an "elevated" profile by 0.002 units ($p<.001$). Finally, individual's average posterior probability of exhibiting a "flat" profile was increased by 0.001 units ($p<.01$) for each additional year of age, as illustrated by results in Model 2, Table 3.15.[3]

Second, a multinomial logistic regression was used to identify the relation between age and probability of membership in an overall pattern of cortisol profiles across all days of saliva collection. The SPSS NOMREG procedure delivered a warning of uncertain validity of model

[3] Additional analyses (not shown) did not indicate any evidence for significant age × gender interactions.

fit, due to unexpected singularities in the Hessian matrix. This problem was fixed by setting the smallest outcome category (i.e., "always flat," n=7) to missing for multinomial logistic regression analyses. Thus, the sample size for the outcome variable in these analyses is 1230, rather than 1237. Table 3.16 shows comparisons between individuals always exhibiting a "typical" profile with respondents showing other combinations of patterns throughout the study. After accounting for the relevant control variables described above, age significantly predicted cortisol pattern membership, when compared to the "always typical" category. Specifically, each additional year of age on the part of a participant was associated with a 6% increased odds of exhibiting an "always elevated" pattern (p<.01), a 6% increased odds of exhibiting an "elevated and flat" pattern (p<.001), and a nearly insignificant 1% increase in the odds of exhibiting an "elevated and typical" pattern (p=.049).

Aim 3: Age and Stressor Differences in Diurnal Cortisol Profiles

The objective in Aim 3 was to examine the degree to which stressors moderate age differences on diurnal cortisol profiles. According to hypotheses stated in the *Introduction*, exposure to stressors would be associated with a stronger association between age and a "high-flat" cortisol profile, and a weaker association between age and "typical" profile. The goal was to distinguish between stressor forms (i.e., life events, chronic stressors, daily stressors) in these moderation analyses. Based on some previous evidence, three conjectures stated that higher chronic stress would be related to a stronger association between age and a "high-flat" profile (e.g., Ritvanen et al., 2006), higher life events would be related to a stronger association between age and a "low-flat" profile (e.g., Yehuda et al., 1995), greater daily stressor burden would further increase age-related risk of exhibiting a "high-flat" diurnal cortisol (e.g., Stawski et al., 2011).

Results from the first set of analyses, as shown in Tables 3.17, 3.18 and 3.19, present age × stressors interactions on individual's average posterior probabilities of exhibiting the "typical," "elevated," and "flat" cortisol profiles, respectively. Table 3.20 presents findings from the categorical approach, which tested age × stressor interactions on probability of diurnal cortisol patterns across all saliva collection days. Model 2 of Table 3.17 shows that older age and higher report of chronic stressors are associated with a lower average posterior probability of exhibiting a "typical" profile ($p<.05$); moreover, Model 3 demonstrated a significant age × chronic stressors interaction ($p<.01$) and a significant age × life events interaction ($p<.05$).

Tests of simple slopes,[4] as illustrated graphically in Figure 3.7, confirmed that the level of chronic stress was associated with a lower average posterior probability of exhibiting a "typical" profile among younger adults ($p<.001$). In contrast, Figure 3.8 demonstrates results from tests of simple slopes, showing that a higher score on a measure of life events was associated with a greater average posterior probability of exhibiting a "typical" profile ($p<.001$).

Results examining age × stressor interactions on average posterior probability of exhibiting an "elevated" profile, presented in Table 3.18, showed significant moderation of life events by age ($p<.05$). Tests of simple slopes, demonstrated in Figure 3.9, further show that although age is generally related to a higher average posterior probability of exhibiting an elevated profile, greater life events among younger participants were related to a lower average posterior probability of exhibiting an "elevated" profile ($p<.001$).

Table 3.19 demonstrates results examining age × stressor interactions on average posterior probability of exhibiting a "flat" profile, signifying a significant interaction between age and chronic stressors ($p<.05$). Tests of simple slopes, shown in Figure 3.10, confirm that whereas chronic stressors were not related to average posterior probability of exhibiting a "flat"

[4] All tests of simple slopes compared the effect of stressors on the relation between age and cortisol outcomes.

profile among older participants, younger participants reporting greater chronic stressors show a greater average posterior probability of exhibiting a "flat" profile, when compared to younger adults who experience fewer chronic stressors ($p<.001$).

Results testing age × stressor interactions on a categorical measure of cortisol profiles across all days of saliva collection using a multinomial logistic regression framework are presented in Table 3.20. Although no support was found for the moderation of age by life events, there were significant age × chronic stressor interactions, when comparing the likelihood of "always typical" to "elevated and flat" profile membership ($p<.01$), and when comparing "always typical" to "elevated and typical" profile membership ($p<.05$). In reference to the probability of exhibiting an "always typical" pattern of cortisol across the entire study period, young adults who reported greater chronic stressors were more likely to exhibit an "elevated and flat" pattern (see Figure 3.11) or an "elevated and typical" pattern (see Figure 3.12). In contrast to the approach testing the continuous outcome, analyses from the categorical approach did not show evidence of significant moderation of age by life events.[5]

[5] This lack of support for moderation of age by life events suggested that significant moderation of life events presented in Tables 3.18 and 3.19 may have resulted from issues of collinearity. As a response, analyses for life events, excluding all other stressors, were rerun. Results continued to support no significant moderation by life events using the categorical approach, and showed that results predicting average posterior probability of exhibiting an "elevated" profile were no longer significant. Results predicting average posterior probability of exhibiting a "typical" profile showed a reduced, but still significant moderation of life events ($p=.039$).

Table 3.1

Descriptive Statistics of Cortisol Values across Days of Saliva Collection

	Saliva Day 1 (*n*=1,465)		Saliva Day 2 (*n*=1,402)		Saliva Day 3 (*n*=1,282)		Saliva Day 4 (*n*=1,004)	
Cortisol Sample	*M (SD)*	Min-Max	*M (SD)*	Min-Max	*M (SD)*	Min-Max	*M (SD)*	Min-Max
Waking	15.03 (8.74)	0.01-58.51	14.97 (8.42)	0.09-58.28	14.95 (8.29)	0.07-56.68	14.84 (7.92)	0.09-58.28
30m Post-Waking	21.55 (11.32)	0.05-59.58	21.07 (10.51)	0.25-59.22	21.57 (11.20)	0.10-59.74	21.18 (10.87)	0.06-59.51
Before Lunch	7.02 (4.49)	0.02-33.40	6.66 (4.21)	0.12-35.27	6.77 (4.49)	0.04-31.46	6.81 (4.55)	0.20-46.49
Before Bedtime	2.84 (3.41)	0.01-28.22	2.79 (3.21)	0.02-30.37	2.81 (3.36)	0.03-30.74	3.12 (4.02)	0.04-32.54

Table 3.2

Saliva Collection Day 1: Fit of Growth Mixture Models

	1-Class	2-Class	3-Class	4-Class
Log-likelihood replication	yes	yes	yes	no
Model Fit Information				
Log-likelihood H0 Value	-18794.67	-17959.61	-17683.67	-
# of parameters	11	19	27	-
AIC	37611.35	35957.23	35421.33	-
BIC	37669.53	36057.73	35564.15	-
Adjusted BIC	37634.59	35997.37	35478.38	-
Entropy		0.87	0.77	-
LMR *p*-value		<0.0001	0.0003	-
LMR adjusted *p*-value		<0.0001	0.0004	-
BLRT *p*-value		<0.0001	<0.0001	-
Residual Variances				
Wake	50.46	56.21	39.55	-
30min	67.05	98.13	94.64	-
Lunch	14.72	6.70	7.57	-
Bed	7.11	1.12	0.25	-

Table 3.3

Saliva Collection Day 2: Fit of Growth Mixture Models

	1-Class	2-Class	3-Class	4-Class
Log-likelihood replication	yes	yes	yes	no
Model Fit Information				
Loglikelihood H0 Value	-17676.20	-17004.60	-16728.95	-
# of parameters	11	19	27	-
AIC	35374.41	34047.20	33511.90	-
BIC	35432.11	34146.88	33653.54	-
Adjusted BIC	35397.17	34086.52	33567.77	-
Entropy		0.74	0.78	-
LMR *p*-value		0.0002	0.0003	-
LMR adjusted *p*-value		0.0002	0.0004	-
BLRT *p*-value		<0.0001	<0.0001	-
Residual Variances				
Wake	48.82	39.85	37.95	-
30min	58.00	71.72	76.51	-
Lunch	13.30	16.48	7.78	-
Bed	7.22	0.69	0.29	-

Table 3.4

Saliva Collection Day 3: Fit of Growth Mixture Models

	1-Class	2-Class	3-Class	4-Class
Log-likelihood replication	yes	yes	yes	yes
Model Fit Information				
Loglikelihood H0 Value	-16305.43	-15616.75	-15410.50	-15301.88
# of parameters	11	19	27	35
AIC	32632.85	31271.50	30875.01	30673.76
BIC	32689.57	31369.47	30449.78	30854.23
Adjusted BIC	32654.63	31309.12	30928.46	30743.05
Entropy		0.76	0.81	0.83
LMR *p*-value		<0.0001	0.0004	0.0502
LMR adjusted *p*-value		<0.0001	0.0004	0.0523
BLRT *p*-value		<0.0001	<0.0001	0.6667
Residual Variances				
Wake	44.34	46.38	32.74	37.45
30min	62.74	40.34	86.24	75.39
Lunch	14.27	17.60	8.22	6.51
Bed	7.51	0.58	0.57	0.46

Table 3.5

Saliva Collection Day 4: Fit of Growth Mixture Models

	1-Class	2-Class	3-Class	4-Class
Log-likelihood replication	yes	yes	yes	yes
Model Fit Information				
Loglikelihood H0 Value	-12917.68	-12336.51	-12130.52	-12021.48
# of parameters	11	19	27	35
AIC	25857.36	24711.03	24315.04	24112.96
BIC	25911.39	24804.35	24447.66	24284.87
Adjusted BIC	25876.45	24744.01	24361.91	24173.71
Entropy		0.91	0.75	0.79
LMR *p*-value		<0.0001	<0.0001	<0.0001
LMR adjusted *p*-value		<0.0001	0.0001	<0.0001
BLRT *p*-value		<0.0001	<0.0001	<0.0001
Residual Variances				
Wake	40.59	48.44	43.70	43.11
30min	63.98	103.11	89.81	71.63
Lunch	15.67	7.94	9.28	7.77
Bed	12.75	2.03	0.35	0.32

Table 3.6

Saliva Collection Day 1: Parameter Estimates for Growth Mixture Models

	Class 1
Est. class counts and proportions	1465.00
Final class counts and proportions	1465
Ave. posterior probabilities	1.00
Intercept mean	15.07
Slope mean	-12.20
Slope loading	
Wake	0.00
30min	-0.53
Lunch	0.67
Bed	1.00
Intercept variance	26.12
Slope variance	25.26

	Class 1	Class 2
Est. class counts and proportions	1221.46 (83%)	243.54 (17%)
Final class counts and proportions	1268 (84%)	230 (16%)
Ave. posterior probabilities	0.97	0.92
Intercept Mean	15.30	11.76
Slope Mean	-13.41	-4.11
Slope Loadings		
Wake	0.00	0.00
30min	-0.47	-0.62
Lunch	0.69	-0.25
Bed	1.00	1.00
Intercept variance	19.40	23.52
Slope variance	16.35	52.13

	Class 1	Class 2	Class 3
Est. class counts and proportions	969.65 (66%)	344.22 (24%)	151.13 (10%)
Final class counts and proportions	1024 (70%)	303 (21%)	137 (9%)
Ave. posterior probabilities	0.92	0.86	0.91
Intercept Mean	13.37	20.41	13.45
Slope Mean	-11.91	-16.29	-4.72
Slope Loading			
Wake	0.00	0.00	0.00
30min	-0.57	-0.19	-0.70
Lunch	0.62	0.84	-0.37
Bed	1.00	1.00	1.00
Intercept variance	9.33	78.43	19.42
Slope variance	7.96	94.63	63.23

Table 3.7

Saliva Collection Day 2: Parameter Estimates for Growth Mixture Models

	Class 1
Est. class counts and proportions	1402.00
Final class counts and proportions	1402
Ave. posterior probabilities	1.00
Intercept Mean	14.95
Slope Mean	-12.13
Slope Loading	
Wake	0.00
30min	-0.51
Lunch	0.69
Bed	1.00
Intercept variance	23.23
Slope variance	20.85

	Class 1	Class 2
Est. class counts and proportions	1045.91 (75%)	356.09 (25%)
Final class counts and proportions	1099 (78%)	303 (22%)
Ave. posterior probabilities	0.94	0.94
Intercept Mean	13.52	19.71
Slope Mean	-11.94	-13.39
Slope Loadings		
Wake	0.00	0.00
30min	-0.54	-0.23
Lunch	0.62	0.79
Bed	1.00	1.00
Intercept variance	10.23	60.30
Slope variance	9.24	96.17

	Class 1	Class 2	Class 3
Est. class counts and proportions	950.00 (68%)	335.57 (24%)	156.54 (8%)
Final class counts and proportions	998 (70%)	299 (21%)	105 (7%)
Ave. posterior probabilities	0.92	0.87	0.91
Intercept Mean	13.49	20.07	12.35
Slope Mean	-12.03	-15.55	-3.70
Slope Loading			
Wake	0.00	0.00	0.00
30min	-0.55	-0.19	-0.49
Lunch	0.63	0.87	-0.48
Bed	1.00	1.00	1.00
Intercept variance	11.32	65.18	15.13
Slope variance	10.31	70.53	57.07

Table 3.8

Saliva Collection Day 3: Parameter Estimates for Growth Mixture Models

	Class 1
Est. class counts and proportions	1282.00
Final class counts and proportions	1282
Ave. posterior probabilities	1.00
Intercept Mean	14.92
Slope Mean	-12.09
Slope Loading	
Wake	0.00
30min	-0.56
Lunch	0.68
Bed	1.00
Intercept variance	26.57
Slope variance	22.24

	Class 1	Class 2
Est. class counts and proportions	950.95 (74%)	331.05 (26%)
Final class counts and proportions	986 (77%)	296 (23%)
Ave. posterior probabilities	0.94	0.93
Intercept Mean	14.54	16.14
Slope Mean	-12.96	-9.83
Slope Loadings		
Wake	0.00	0.00
30min	-0.36	-1.21
Lunch	0.64	0.70
Bed	1.00	1.00
Intercept variance	19.79	32.24
Slope variance	17.63	45.93

	Class 1	Class 2	Class 3
Est. class counts and proportions	923.88 (72%)	250.66 (20%)	107.47 (8%)
Final class counts and proportions	963 (75%)	226 (18%)	93 (7%)
Ave. posterior probabilities	0.94	0.87	0.90
Intercept Mean	13.70	20.18	14.16
Slope Mean	-12.18	-15.12	-5.57
Slope Loading			
Wake	0.00	0.00	0.00
30min	-0.56	-0.16	-0.66
Lunch	0.63	0.91	-0.28
Bed	1.00	1.00	1.00
Intercept variance	15.71	78.32	25.36
Slope variance	13.62	92.03	67.95

Table 3.8
Continued

	Class 1	Class 2	Class 3	Class 4
Est. class counts and proportions	893.59 (70%)	232.94 (18%)	94.08 (7%)	61.38 (5%)
Final class counts and proportions	940 (73%)	203 (16%)	81 (6%)	58 (5%)
Ave. posterior probabilities	0.93	0.87	0.90	0.91
Intercept Mean	13.84	19.90	15.66	11.52
Slope Mean	-12.36	-15.04	-12.32	1.99
Slope Loading				
Wake	0.00	0.00	0.00	0.00
30min	-0.53	-0.25	-0.81	3.58
Lunch	0.65	0.91	-0.11	-1.90
Bed	1.00	1.00	1.00	1.00
Intercept variance	16.61	66.79	17.32	30.12
Slope variance	14.66	71.78	12.62	1.68

Table 3.9

Saliva Collection Day 4: Parameter Estimates for Growth Mixture Models

	Class 1
Est. class counts and proportions	1004.00
Final class counts and proportions	1004
Ave. posterior probabilities	1.00
Intercept Mean	14.81
Slope Mean	-11.65
Slope Loading	
Wake	0.00
30min	-0.55
Lunch	0.69
Bed	1.00
Intercept variance	23.60
Slope variance	17.65

	Class 1	Class 2
Est. class counts and proportions	876.55 (87%)	127.45 (13%)
Final class counts and proportions	885 (88%)	119 (12%)
Ave. posterior probabilities	0.98	0.94
Intercept Mean	14.82	11.91
Slope Mean	-12.74	-1.51
Slope Loadings		
Wake	0.00	0.00
30min	-0.48	-0.36
Lunch	0.69	-0.64
Bed	1.00	1.00
Intercept variance	13.55	21.59
Slope variance	9.30	50.31

	Class 1	Class 2	Class 3
Est. class counts and proportions	594.19 (59%)	324.01 (32%)	85.80 (9%)
Final class counts and proportions	640 (64%)	285 (28%)	79 (8%)
Ave. posterior probabilities	0.89	0.90	0.95
Intercept Mean	13.57	16.91	13.39
Slope Mean	-12.28	-12.84	-1.21
Slope Loading			
Wake	0.00	0.00	0.00
30min	-0.46	-0.51	-0.26
Lunch	0.62	0.79	-0.70
Bed	1.00	1.00	1.00
Intercept variance	9.67	26.95	22.39
Slope variance	8.58	30.06	64.46

Table 3.9
Continued

	Class 1	Class 2	Class 3	Class 4
Est. class counts and proportions	589.75 (59%)	304.06 (30%)	68.87 (7%)	41.31 (4%)
Final class counts and proportions	638 (64%)	270 (27%)	60 (6%)	36 (4%)
Ave. posterior probabilities	0.89	0.88	0.89	0.94
Intercept Mean	13.49	17.15	15.76	13.84
Slope Mean	-12.19	-13.15	-8.86	2.49
Slope Loading				
Wake	0.00	0.00	0.00	0.00
30min	-0.46	-0.51	-0.98	3.11
Lunch	0.62	0.82	-0.24	-3.44
Bed	1.00	1.00	1.00	1.00
Intercept variance	10.21	29.47	28.23	31.11
Slope variance	9.27	32.46	40.20	2.06

Table 3.10
Pearson Correlations between Self-Reported Characteristics and Average Posterior Probabilities of Cortisol Profiles

Variables	Ave. posterior probability of typical profile	Ave. posterior probability of elevated profile	Ave. posterior probability of flat profile
Age	-.159***	.128***	.103***
Lag (MIDUS to NSDE, yrs)	.040	-.042	-.012
Gender (1=*female*)	.106***	-.055	-.116***
College degree or more	.023	-.020	.011
Caucasian[a]	.082**	-.044	-.087**
African American[b]	-.104***	.087**	.062*
Currently married/partnered	.027	-.030	-.005
Currently working	.119***	-.089**	-.088**
Has 1 or more children	-.001	-.016	.025
Had period within last year[c]	.014	-.039	.037
Any alcohol	.007	.003	-.018
Any cigarettes	-.124***	.066*	.132***
Any medications	-.019	-.041	.026
Self-rated health	.086**	-.022	-.127***
Number of chronic conditions	-.050	.036	.040
Daily stressors	.074**	-.049	-.063*
Average number	.075**	-.050	-.064*
Average severity	.058*	-.039	-.050
Chronic stress	.037	-.041	-.007
Life events	.011	<.001	.020
Childhood Stressors	.061*	-.050	-.038
Adult Life Events	-.018	.002	.031

Note: [a]Caucasian: 0 = *not Caucasian*, 1 = *Caucasian*.
[b]African American: 0 = *not African American.* 1 = *African American*.
[c]Tested only among women.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.11
Pearson Correlations between Self-Reported Characteristics and Patterns of Combinations of Cortisol Profiles

	Always Typical Versus					
Variables	Always Flat	Always Elevated	Elevated & Flat	Elevated & Typical	Flat & Typical	Elevated, Flat & Typical
Age	.038	.117**	.194***	.083*	.065	.029
Lag (MIDUS to NSDE, yrs.)	.026	.045	.011	-.069*	.064	-.030
Gender (1=*female*)	-.045	<.001	.167***	-.082*	-.121**	-.105**
College degree or more	.006	-.039	-.050	.051	.027	.014
Caucasian[a]	-.020	-.059	-.139**	.014	-.019	-.047
African American[b]	-.025	.097*	.177**	.032	.003	.085*
Currently married/partnered	.025	-.065	.022	-.029	-.013	-.010
Currently working	-.038	-.147**	-.145***	-.037	-.042	-.057
Has 1 or more children	.045	-.037	-.005	.024	.011	.073
Had period within last year[c]	.015	-.075	.083	-.001	-.030	.054
Any alcohol	-.013	-.053	-.021	.034	.035	.031
Any cigarettes	.013	.085*	.119**	.043	.140***	.145***
Any medications	.011	-.029	.003	.055	-.003	.006
Self-rated health	-.033	-.023	-.100*	.018	-.089*	-.049
Number of chronic conditions	.030	.062	.022	-.016	-.027	-.013
Daily stressors	.004	-.083*	-.073	-.015	.011	-.086*
Average number	-.021	-.077	-.085*	-.004	.040	-.087*
Average severity	.027	-.071	-.045	-.022	-.021	-.069
Chronic stress	.024	-.076	-.046	-.010	.017	.008
Life events	-.011	.022	.034	-.005	.047	-.003
Childhood Stressors	-.055	-.031	-.044	-.038	.023	-.037
Adult Life Events	-.018	.038	.013	.006	.057	.007

Note: [a]Caucasian: 0 = *not Caucasian*, 1 = *Caucasian*.
[b]African American: 0 = *not African American.* 1 = *African American*.
[c]Tested only among women.
All stressor variables were standardized.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.12

Pattern of Cortisol Profiles: Number and Proportion of Participants, Mean Differences on Substantive Variables

Variables	Always Flat (a)	Always Elevated (b)	Always Typical (c)	Elevated & Flat (d)	Elevated & Typical (e)	Flat & Typical (f)	Elevated, Flat & Typical (g)
n	7	37	534	49	103	407	100
Percent of sample (%)	.6	3.0	43.2	4.0	8.3	32.9	8.1
Age at saliva collection (yrs.)	60.37	$64.68_{c,e,f,g}$	$56.67_{b,d,e}$	$64.59_{c,e,f,g}$	$58.58_{b,c,d}$	$58.51_{b,d}$	$57.46_{b,d}$
Lag (MIDUS to NSDE, yrs.)	1.66	1.71	1.92_{e}	1.93	1.76_{c}	1.72	1.82
Self-rated health	3.43	3.62	$3.71_{d,f}$	$3.37_{c,e}$	$3.48_{d,f}$	$4.74_{c,e}$	3.58
Number of chronic conditions	3.00	2.97	2.39	2.57	2.22	2.31	2.30
Daily stressors	.06	$-.30_{c}$	$.02_{b,g}$	-.23	.05	-.01	$-.20_{c}$
Average number	-.18	$-.30_{f}$	$-.02_{d,g}$	$-.29_{c,e,f}$	$.08_{c,g}$	$-.02_{b,d,g}$	$-.23_{c,e,f}$
Average severity	.25	-.23	.03	-.24	-.02	-.01	-.14
Chronic stress	.16	-.32	-.04	-.19	.01	-.06	-.02
Life events	-.16	.02	-.07	.05	.05	-.08	-.08
Childhood Stressors	-.53	-.15	-.03	-.19	.04	-.10	-.13
Adult Life Events	.05	.06	$-.08_{f}$	-.03	.07	$-.65_{c}$	-.06

Note: All stressor variables were standardized.

$_{a, b, c, d, e, f g}$ Means are significantly different from groups labeled $_{a}$ through $_{f}$ at $p < .05$, using LSD post-hoc comparisons.

Table 3.13

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting a Typical Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*
Any cigarettes	-0.096 (0.023)***	-0.112 (0.023)***
Any medications	-0.002 (0.017)	-0.009 (0.017)
Gender (1=*female*)	0.070 (0.017)***	0.061 (0.017)***
Caucasian	0.070 (0.028)*	0.076 (0.027)**
College degree or more	<0.001 (0.017)	-0.003 (0.017)
Currently married/partnered	0.008 (0.020)	-0.006 (0.020)
Currently working	0.078 (0.018)***	0.034 (0.020)
Has 1 or more children	-0.001 (0.026)	0.018 (0.026)
Lag (MIDUS to NSDE, yrs.)	0.010 (0.007)	0.011 (0.007)
Age (yrs.)		-0.004 (0.001)***
Adjusted R^2	0.043	0.058
R^2 change		0.016***

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.14

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting an Elevated Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*
Any cigarettes	0.040 (0.019)*	0.051 (0.019)**
Any medications	-0.013 (0.014)	-0.009 (0.014)
Gender (1=*female*)	-0.027 (0.014)	-0.021 (0.014)
Caucasian	-0.028 (0.023)	-0.032 (0.023)
College degree or more	-0.003 (0.014)	-0.001 (0.014)
Currently married/partnered	-0.007 (0.017)	0.002 (0.017)
Currently working	-0.046 (0.015)**	-0.017 (0.017)
Has 1 or more children	-0.011 (0.021)	-0.023 (0.022)
Lag (MIDUS to NSDE, yrs.)	-0.008 (0.006)	-0.009 (0.006)
Age (yrs.)		0.002 (0.001)***
Adjusted R^2	0.013	0.023
R^2 change		0.011***

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.15

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting a Flat Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*
Any cigarettes	0.056 (0.012)**	0.062 (0.012)***
Any medications	0.016 (0.009)	0.018 (0.009)*
Gender (1=*female*)	-0.043 (0.009)***	-0.040 (0.009)***
Caucasian	-0.043 (0.015)**	-0.044 (0.015)**
College degree or more	0.003 (0.009)	0.004 (0.009)
Currently married/partnered	-0.001 (0.011)	0.004 (0.011)
Currently working	-0.032 (0.009)**	-0.017 (0.011)
Has 1 or more children	0.012 (0.014)	0.005 (0.014)
Lag (MIDUS to NSDE, yrs.)	-0.002 (0.004)	-0.002 (0.004)
Age (yrs.)		0.001 (<0.001)**
Adjusted R^2	0.044	0.049
R^2 change		0.006**

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.16

Multinomial Logistic Coefficients and Odds Ratios for Variables Predicting Pattern of Cortisol Membership

	Always Typical Versus									
	Always Elevated		Elevated & Flat		Elevated & Typical		Flat & Typical		Elevated, Flat & Typical	
Predictor	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B
Constant	-4.18 (1.47)**		-4.48 (1.36)**		-0.93 (0.56)		-1.91 (0.91)*		-1.53 (0.93)	
Any cigarettes	1.03 (0.47)*	2.80	1.30 (0.4)**	3.67	0.35 (0.21)	0.43	1.04 (0.28)***	2.83	1.01 (0.28)***	2.75
Any medications	-0.02 (0.38)	0.98	0.34 (0.34)	1.41	-0.15 (0.14)	0.86	0.21 (0.23)	1.23	0.19 (0.23)	1.21
Gender (1=*female*)	<0.01 (0.38)	1.00	-1.33 (0.36)***	0.26	-0.29 (0.14)*	0.75	-0.75 (0.23)**	0.47	-0.71 (0.24)**	0.49
Caucasian	-0.71 (0.51)	0.49	-1.23 (0.41)**	0.29	0.17 (0.25)	1.18	-0.25 (0.37)	0.78	-0.38 (0.35)	0.69
College degree or more	-0.02 (0.38)	0.98	-0.23 0.35	0.79	0.26 (0.14)	1.30	0.22 (0.23)	1.25	0.22 (0.23)	1.25
Married/partnered	0.02 (0.41)	1.02	0.57 0.43	1.76	-0.23 (0.17)	0.79	-0.12 (0.27)	0.88	-0.23 (0.28)	0.79
Currently working	-0.56 (0.42)	0.57	-0.49 0.38	0.61	-0.06 (0.17)	0.95	-0.15 (0.27)	0.86	-0.38 (0.27)	0.68
Has 1 or more children	-0.81 (0.49)	0.45	-0.55 0.48	0.58	0.28 (0.22)	1.32	0.17 (0.36)	1.18	0.91 (0.44)*	2.49
Lag (MIDUS-NSDE)	-0.18 (0.16)	0.84	0.02 (0.14)	1.02	-0.12 (0.06)	0.89	-0.16 (0.1)	0.85	-0.08 (0.1)	0.93
Age (yrs.)	0.05 (0.02)**	1.06	0.06 (0.02)***	1.06	0.01 (0.01)*[1]	1.01	0.02 (0.01)	1.02	<.01 (0.01)	1.00
Model χ^2										139.86***
df										50
Nagelkerke R^2										.116

Note: e^B = odds ratio (exponentiated *B*). The "Always Flat" category was set to missing due to small class size. Always typical is the reference category.

*$p < .05$. **$p < .01$. ***$p < .001$. [1] p=.045.

Table 3.17

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting a Typical Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*	Model 3 *B (SE)*
Any cigarettes	-0.096 (0.023)***	-0.113 (0.023)***	-0.116 (0.023)***
Any medications	-0.002 (0.017)	-0.009 (0.017)	-0.007 (0.017)
Gender (1=*female*)	0.070 (0.017)***	0.059 (0.017)**	0.057 (0.017)**
Caucasian	0.070 (0.028)*	0.075 (0.028)**	0.078 (0.028)**
College degree or more	<0.001 (0.017)	-0.006 (0.017)	-0.005 (0.017)
Currently married/partnered	0.008 (0.020)	-0.002 (0.020)	-0.004 (0.02)
Currently working	0.078 (0.018)***	0.050 (0.021)*	0.041 (0.022)
Has 1 or more children	-0.001 (0.026)	0.020 (0.026)	0.019 (0.026)
Lag (MIDUS to NSDE, yrs.)	0.010 (0.007)	0.011 (0.007)	0.010 (0.007)
Age		-0.048 (0.010)***	-0.045 (0.01)***
Daily stressors		0.007 (0.009)	0.004 (0.009)
Chronic stressors		-0.022 (0.011)*	-0.016 (0.011)*
Life events		0.013 (0.009)	0.009 (0.009)
Age × daily stressors			-0.013 (0.009)
Age × chronic stressors			0.025 (0.009)**
Age × life events			-0.021 (0.009)*
Adjusted R^2	0.043	0.060	0.067
R^2 change		0.020***	0.009**

Note: Age and stressor variables were standardized prior to construction of interactions.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.18

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting an Elevated Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*	Model 3 *B (SE)*
Any cigarettes	0.040 (0.019)*	0.051 (0.019)**	0.053 (0.019)**
Any medications	-0.013 (0.014)	-0.009 (0.014)	-0.010 (0.014)
Gender (1=*female*)	-0.027 (0.014)	-0.021 (0.014)	-0.019 (0.014)
Caucasian	-0.028 (0.023)	-0.031 (0.023)	-0.033 (0.023)**
College degree or more	-0.003 (0.014)	0.001 (0.014)	<0.001 (0.014)
Currently married/partnered	-0.007 (0.017)	<0.001 (0.017)	0.001 (0.017)
Currently working	-0.046 (0.015)**	-0.026 (0.018)	-0.021 (0.018)
Has 1 or more children	-0.011 (0.021)	-0.024 (0.022)	-0.024 (0.022)
Lag (MIDUS to NSDE, yrs.)	-0.008 (0.006)	-0.009 (0.006)	-0.008 (0.006)
Age		0.032 (0.008)***	0.030 (0.009)***
Daily stressors		-0.003 (0.008)	-0.001 (0.008)
Chronic stressors		0.013 (0.009)	0.009 (0.009)
Life events		-0.007 (0.008)	-0.004 (0.008)
Age × daily stressors			0.006 (0.007)
Age × chronic stressors			-0.015 (0.008)
Age × life events			0.015 (0.007)*
Adjusted R^2	0.013	0.022	0.026
R^2 change		0.013**	0.006

Note: Age and stressor variables were standardized prior to construction of interactions.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.19

Linear Regression Coefficients for Variables Predicting Average Posterior Probability of Exhibiting a Flat Profile

	Model 1 *B (SE)*	Model 2 *B (SE)*	Model 3 *B (SE)*
Any cigarettes	0.056 (0.012)***	0.062 (0.013)***	0.063 (0.013)***
Any medications	0.016 (0.009)	0.018 (0.009)	0.018 (0.009)
Gender (1=*female*)	-0.043 (0.009)***	-0.039 (0.009)***	-0.038 (0.009)***
Caucasian	-0.043 (0.015)**	-0.044 (0.015)**	-0.045 (0.015)**
College degree or more	0.003 (0.009)	0.005 (0.009)	0.005 (0.009)
Currently married/partnered	-0.001 (0.011)	0.002 (0.011)	0.003 (0.011)
Currently working	-0.032 (0.009)**	-0.024 (0.012)*	-0.021 (0.012)
Has 1 or more children	0.012 (0.014)	0.005 (0.014)	0.005 (0.014)
Lag (MIDUS to NSDE, yrs.)	-0.002 (0.004)	-0.002 (0.004)	-0.002 (0.004)
Age		0.016 (0.005)**	0.014 (0.006)*
Daily stressors		-0.005 (0.005)	-0.003 (0.005)
Chronic stressors		0.009 (0.006)	0.007 (0.006)
Life events		-0.006 (0.005)	-0.005 (0.005)
Age × daily stressors			0.006 (0.005)
Age × chronic stressors			-0.010 (0.005)*
Age × life events			0.006 (0.005)
Adjusted R^2	0.044	0.050	0.52
R^2 change		0.009*	0.005

Note: Age and stressor variables were standardized prior to construction of interactions.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.20

Multinomial Logistic Coefficients and Odds Ratios for Variables Predicting Pattern of Cortisol Membership

	Always Typical Versus									
	Always Elevated		Elevated & Flat		Elevated & Typical		Flat & Typical		Elevated, Flat & Typical	
Predictor	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B	*B* (*SE*)	e^B
Constant	-1.11 (0.81)		-0.96 (0.75)		-0.25 (0.38)		-0.96 (0.58)		-1.50 (0.63)*	
Any cigarettes	1.08 (0.47)*	2.94	1.36 (0.41)**	3.91	0.34 (0.21)	1.41	1.01 (0.29)***	2.76	1.04 (0.29)***	2.83
Any medications	-0.01 (0.39)	0.99	0.34 (0.34)	1.40	-0.17 (0.15)	0.85	0.18 (0.23)	1.20	0.22 (0.24)	1.24
Gender (1=*female*)	0.10 (0.4)	1.11	-1.33 (0.37)***	0.26	-0.29 (0.15)*	0.75	-0.79 (0.24)**	0.46	-0.65 (0.24)**	0.52
Caucasian	-0.67 (0.52)	0.51	-1.35 (0.43)**	0.26	0.19 (0.25)	1.21	-0.17 (0.38)	0.84	-0.37 (0.37)	0.69
College degree or more	0.09 (0.40)	1.10	-0.22 (0.36)	0.80	0.28 (0.15)	1.32	0.22 (0.24)	1.25	0.27 (0.24)	1.32
Married/partnered	0.06 (0.42)	1.07	0.58 (0.44)	1.79	-0.24 (0.17)	0.79	-0.12 (0.28)	0.89	-0.29 (0.28)	0.75
Currently working	-0.75 (0.46)	0.47	-0.53 (0.42)	0.59	-0.06 (0.19)	0.94	-0.24 (0.30)	0.78	-0.50 (0.30)	0.61
Has 1 or more children	-0.87 (0.50)	0.42	-0.60 (0.49)	0.55	0.27 (0.22)	1.31	0.14 (0.36)	1.15	0.91 (0.44)*	2.50
Lag (MIDUS-NSDE)	-0.17 (0.16)**	0.84	0.02 (0.14)	1.02	-0.11 (0.06)	0.90	-0.16 (0.10)	0.85	-0.07 (0.10)	0.93
Age	0.81 (0.26)	2.24	0.79 (0.24)**	2.20	0.14 (0.09)	1.16	0.24 (0.14)	1.27	-0.01 (0.15)	0.99
Daily stressors	-0.32 (0.25)	0.73	-0.04 (0.21)	0.96	0.02 (0.08)	1.02	0.13 (0.12)	1.14	-0.22 (0.14)	0.80
Chronic stressors	0.32 (0.26)	1.38	0.26 (0.22)	1.30	0.05 (0.09)	1.05	0.09 (0.15)	1.10	0.15 (0.15)	1.16
Life events	-0.16 (0.25)	0.85	-0.23 (0.20)	0.80	-0.04 (0.08)	0.96	0.02 (0.13)	1.02	-0.15 (0.13)	0.86
Age × daily stressors	0.28 (0.22)	1.33	0.26 (0.17)	1.30	0.09 (0.07)	1.10	0.16 (0.12)	1.17	0.13 (0.13)	1.13
Age × chronic stressors	-0.06 (0.21)	0.94	-0.40 (0.15)**	0.67	-0.20 (0.08)*	0.82	-0.08 (0.13)	0.92	-0.06 (0.13)	0.94
Age × life events	0.32 (0.21)	1.38	0.22 (0.17)	1.24	-0.03 (0.08)	0.97	-0.05 (0.12)	0.96	-0.02 (0.13)	0.98
Model χ^2										171.148***
df										80
Nagelkerke R^2										0.140

Note: e^B = odds ratio (exponentiated *B*). The "Always Flat" category was set to missing due to small class size. Always typical is the reference category. Age and stressor variables were standardized prior to construction of interactions.

*$p < .05$. **$p < .01$. ***$p < .001$.

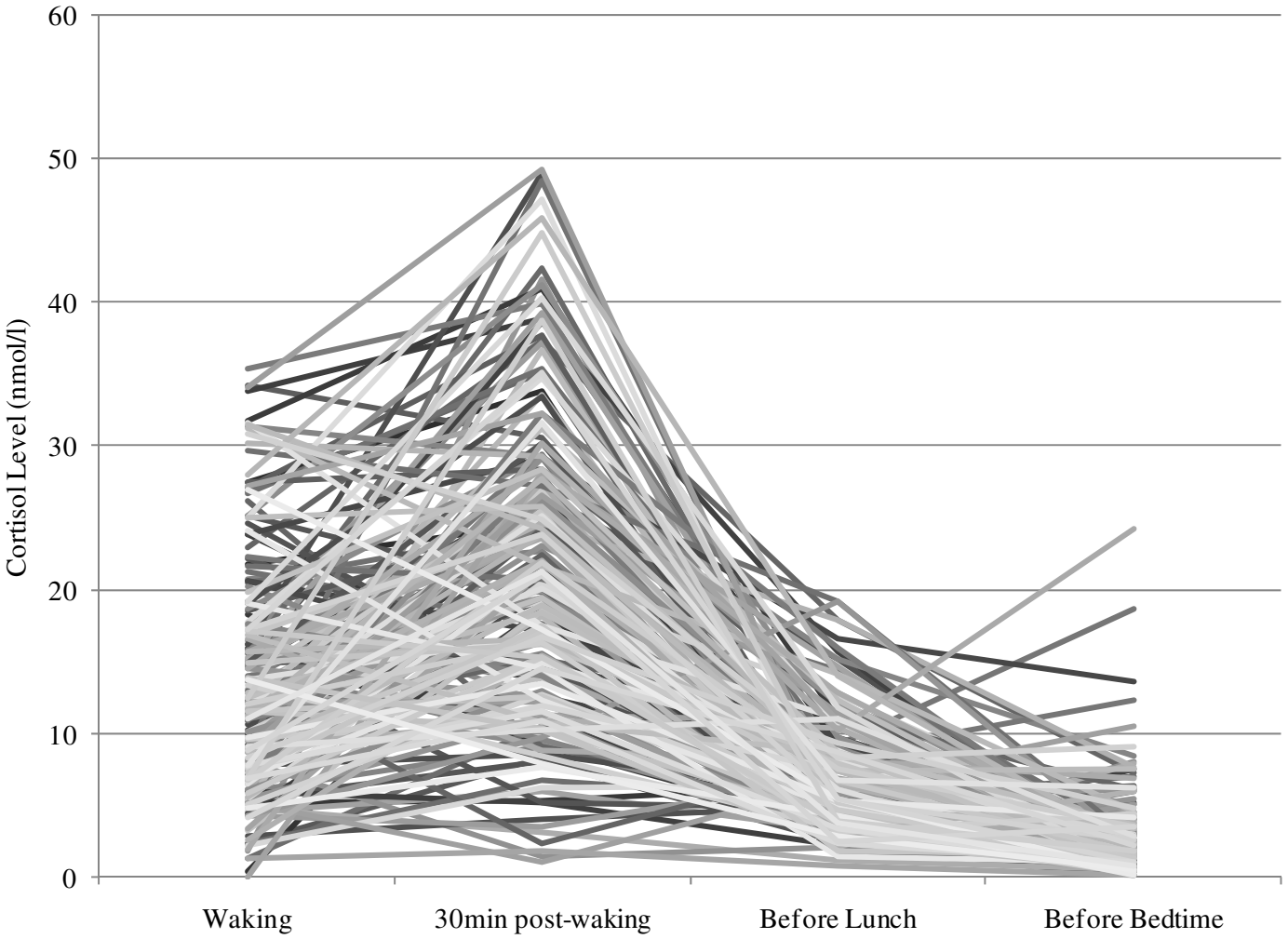

Figure 3.1. Descriptive Plot of 200 Randomly-Selected Cortisol Values from the Saliva Day 1.

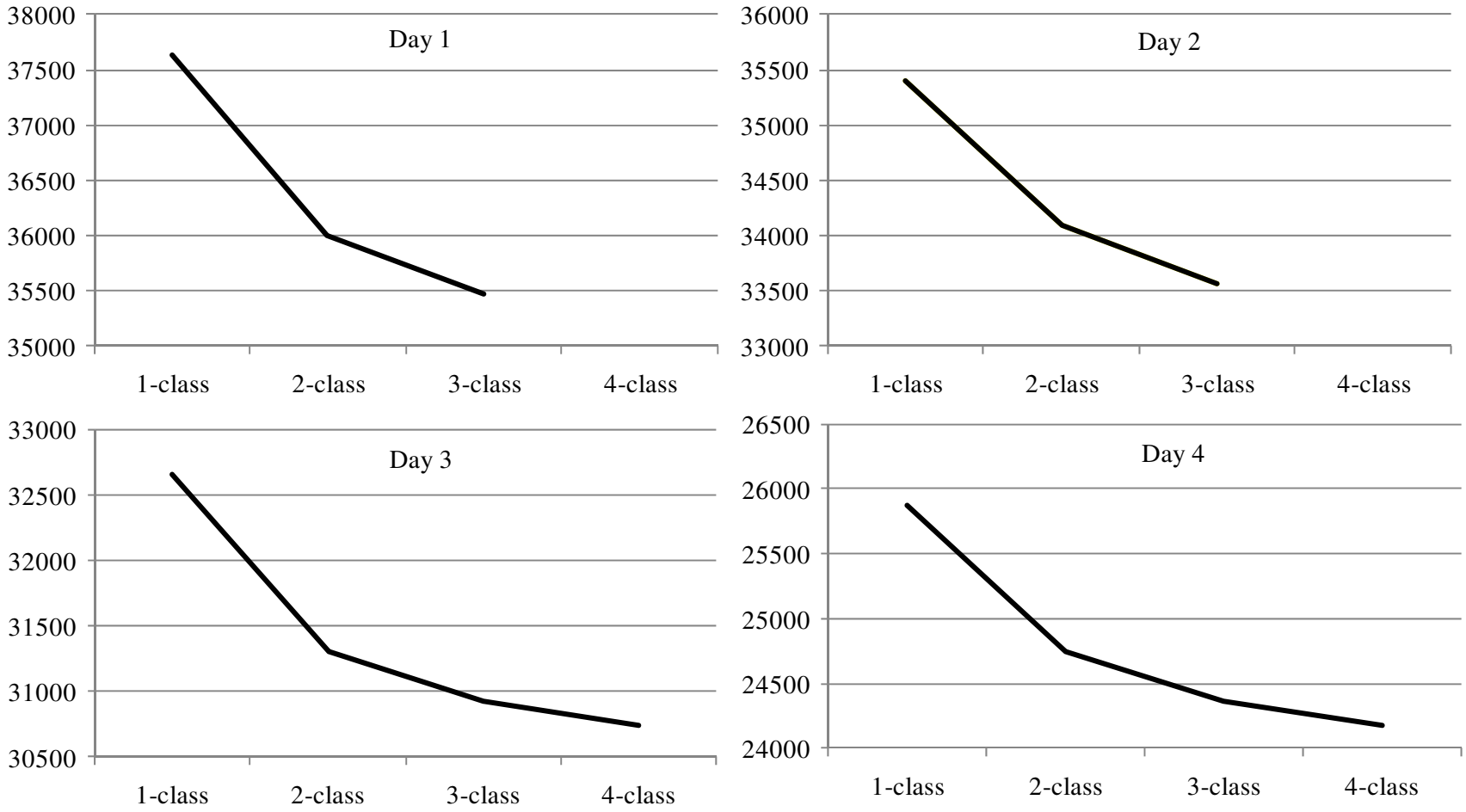

Figure 3.2. Sample-Adjusted BIC Values for Models Estimating Class Solutions across 4 Days of Saliva Collection.

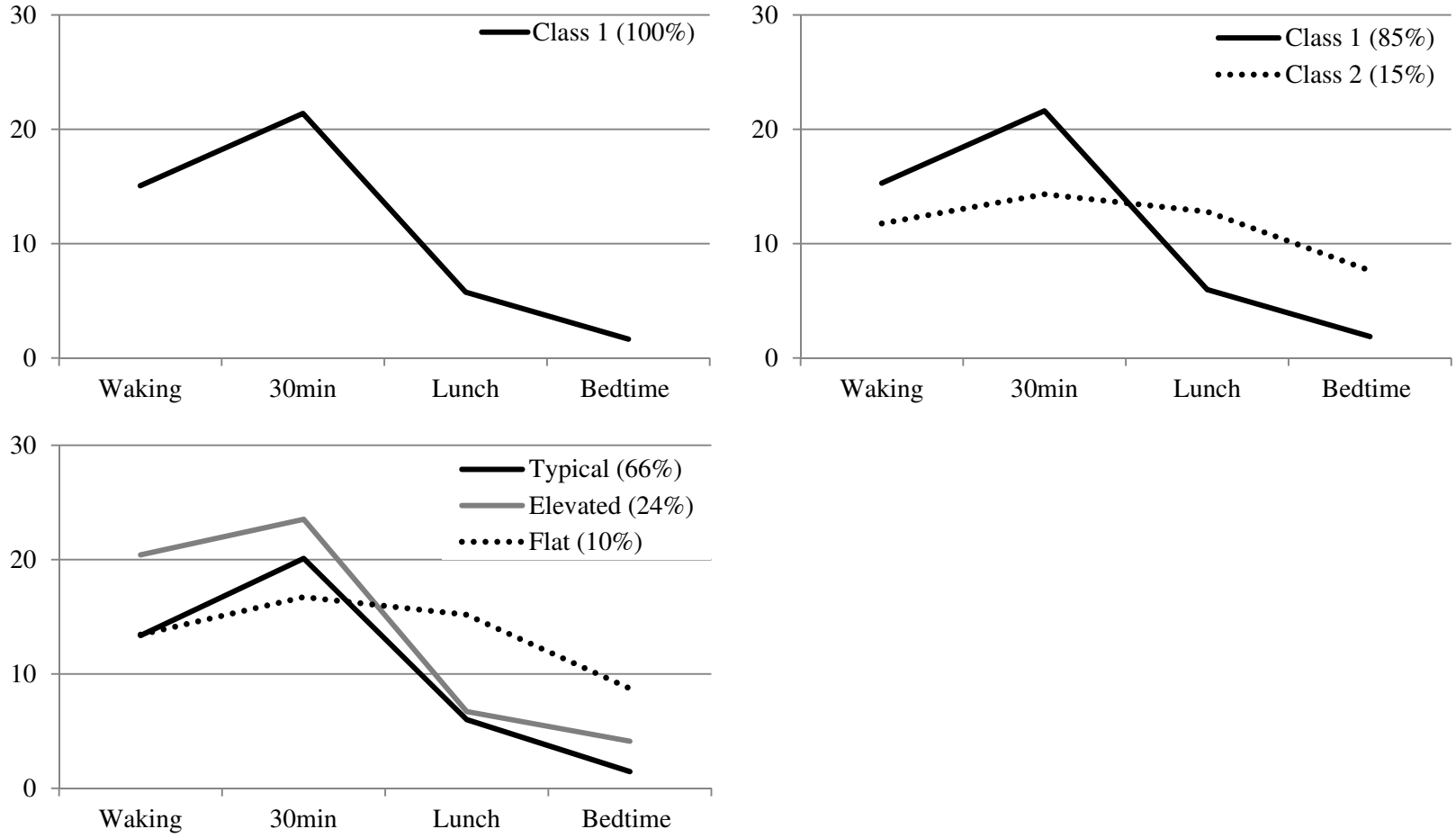

Figure 3.3. Estimated Diurnal Cortisol Profiles and Proportions on Saliva Day 1.

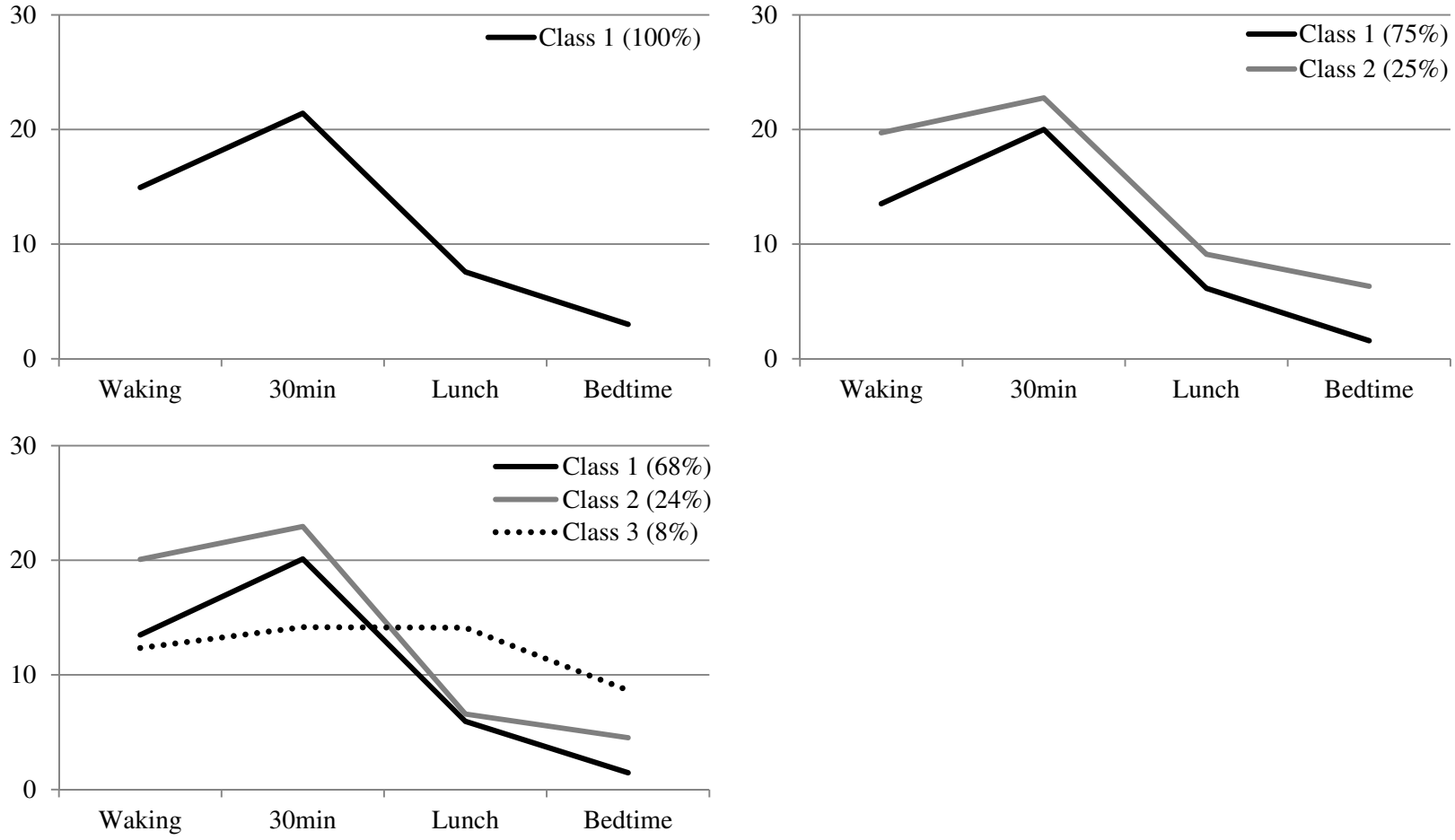

Figure 3.4. Estimated Diurnal Cortisol Profiles and Proportions on Saliva Day 2.

Figure 3.5. Estimated Diurnal Cortisol Profiles and Proportions on Saliva Day 3.

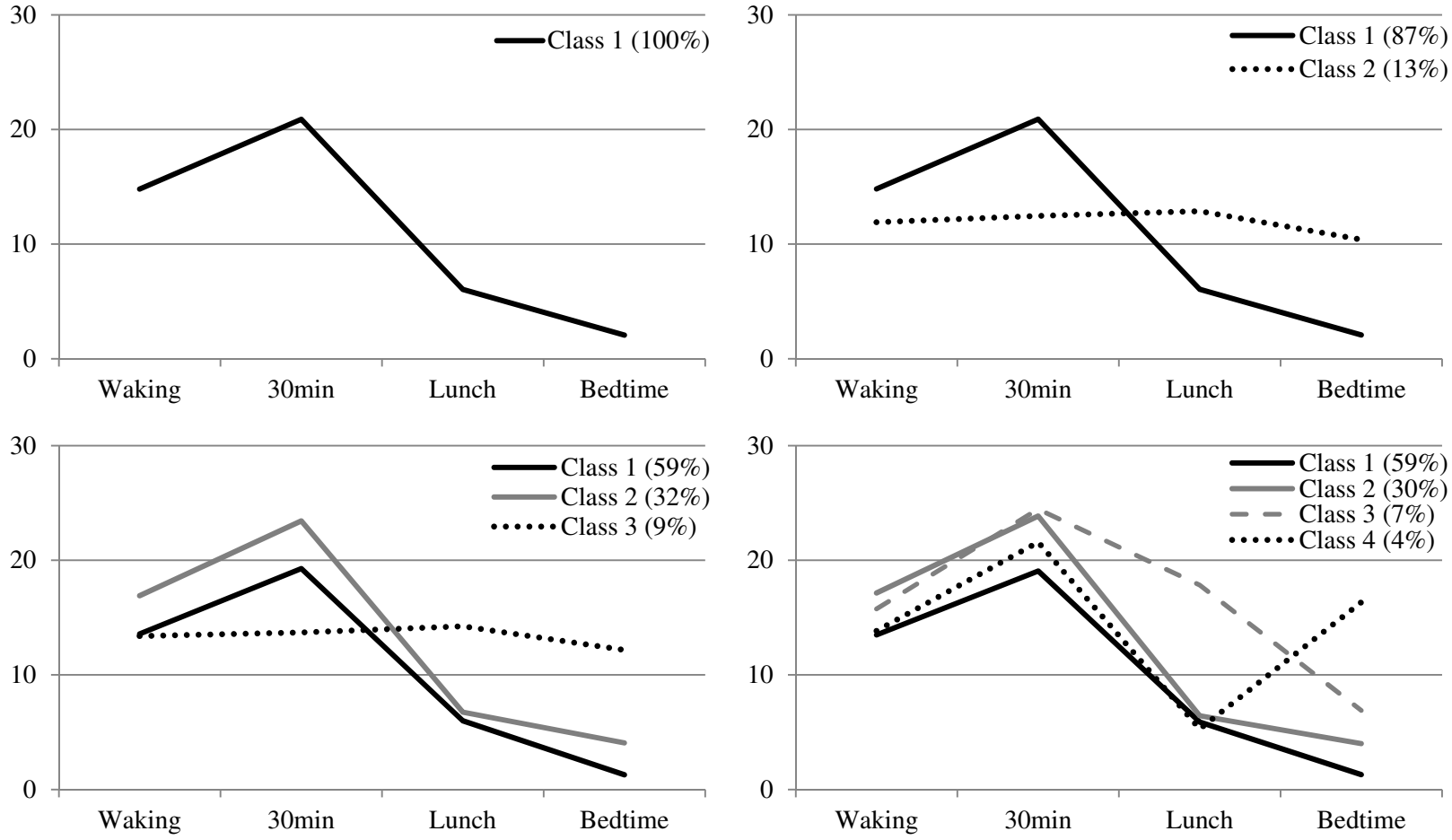

Figure 3.6. Estimated Diurnal Cortisol Profiles and Proportions on Saliva Day 4.

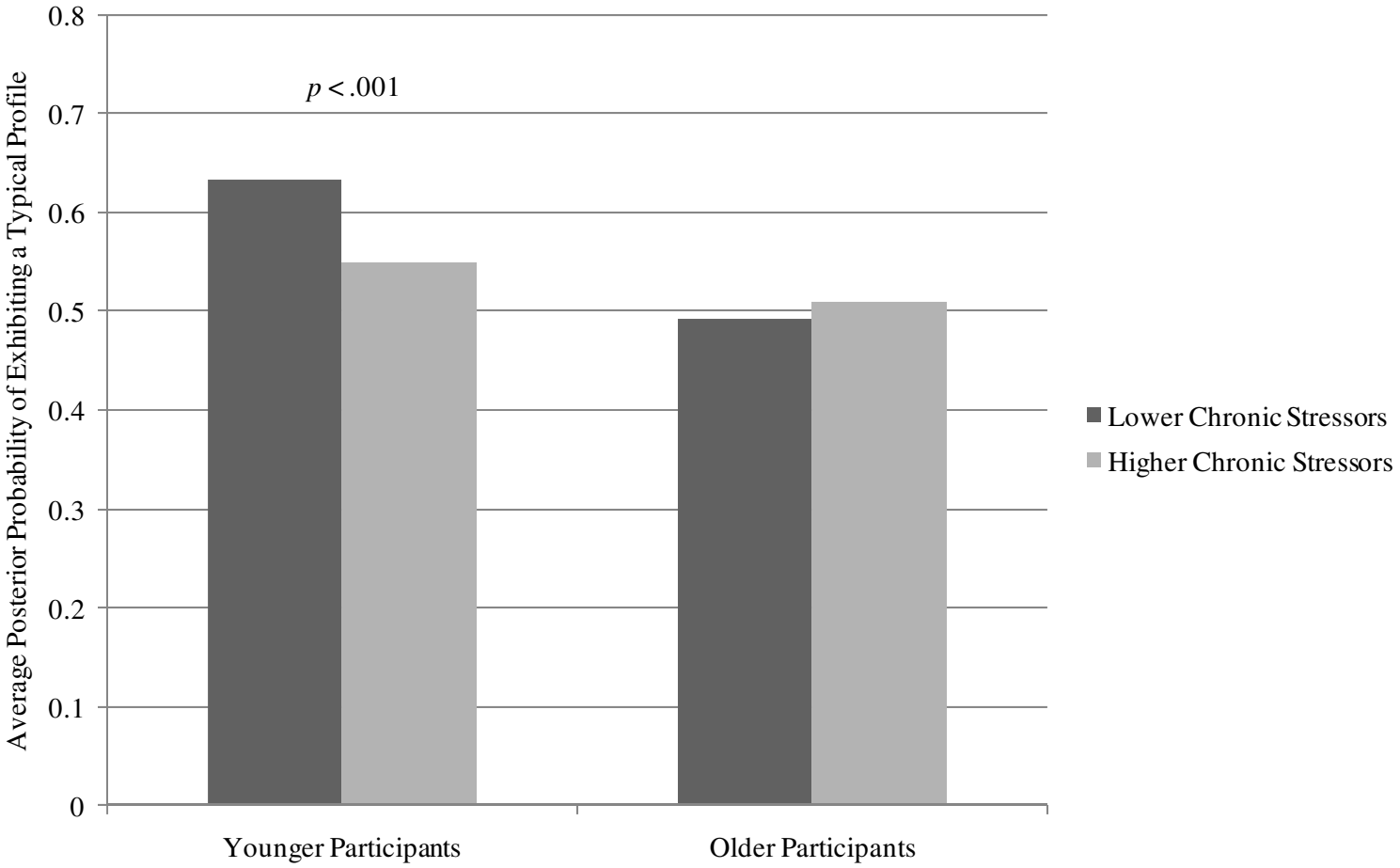

Figure 3.7. Average Posterior Probability of Exhibiting a Typical Profile: Age × Chronic Stressors.

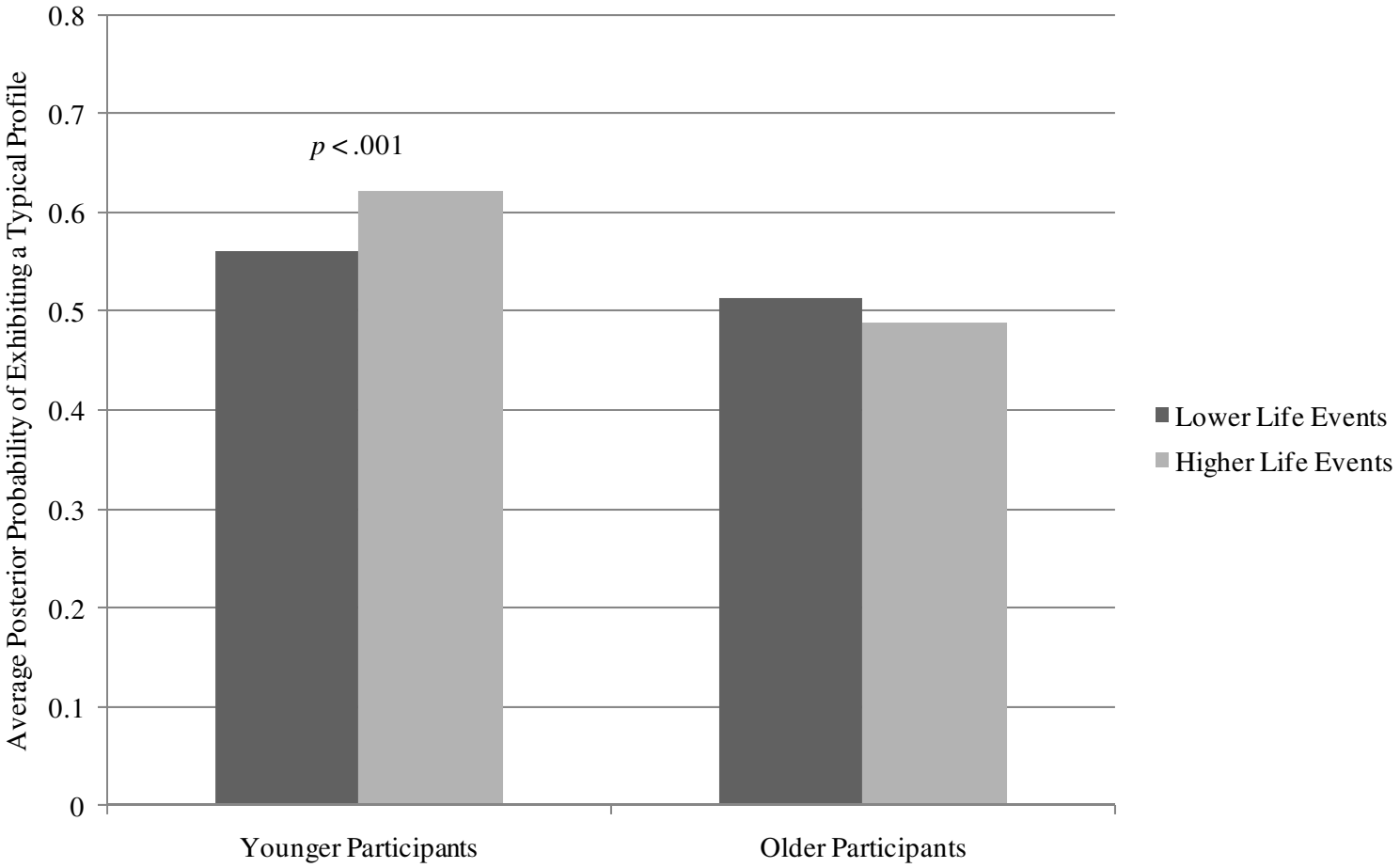

Figure 3.8. Average Posterior Probability of Exhibiting a Typical Profile: Age × Life Events.

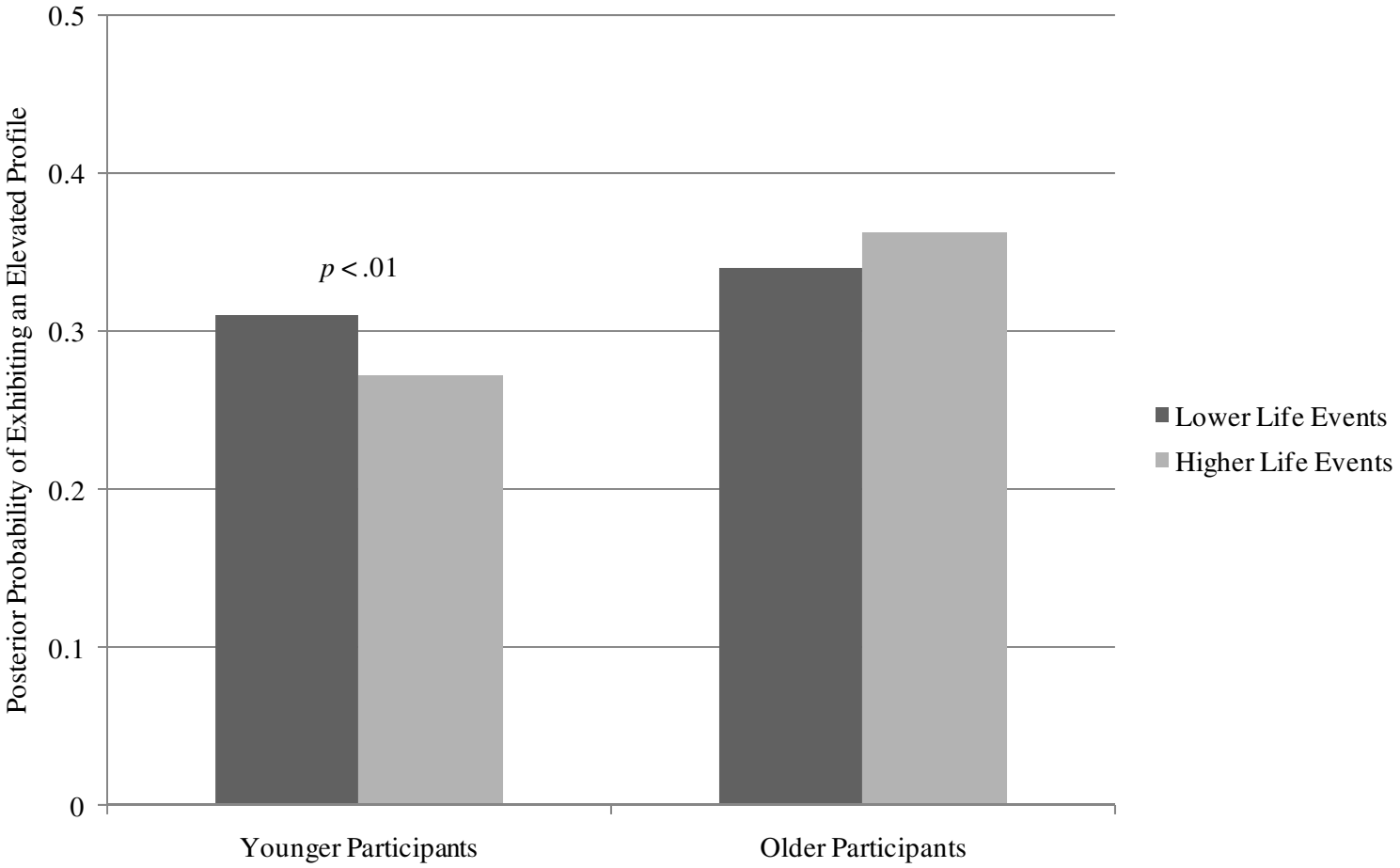

Figure 3.9. Average Posterior Probability of Exhibiting an Elevated Profile: Age × Life Events.

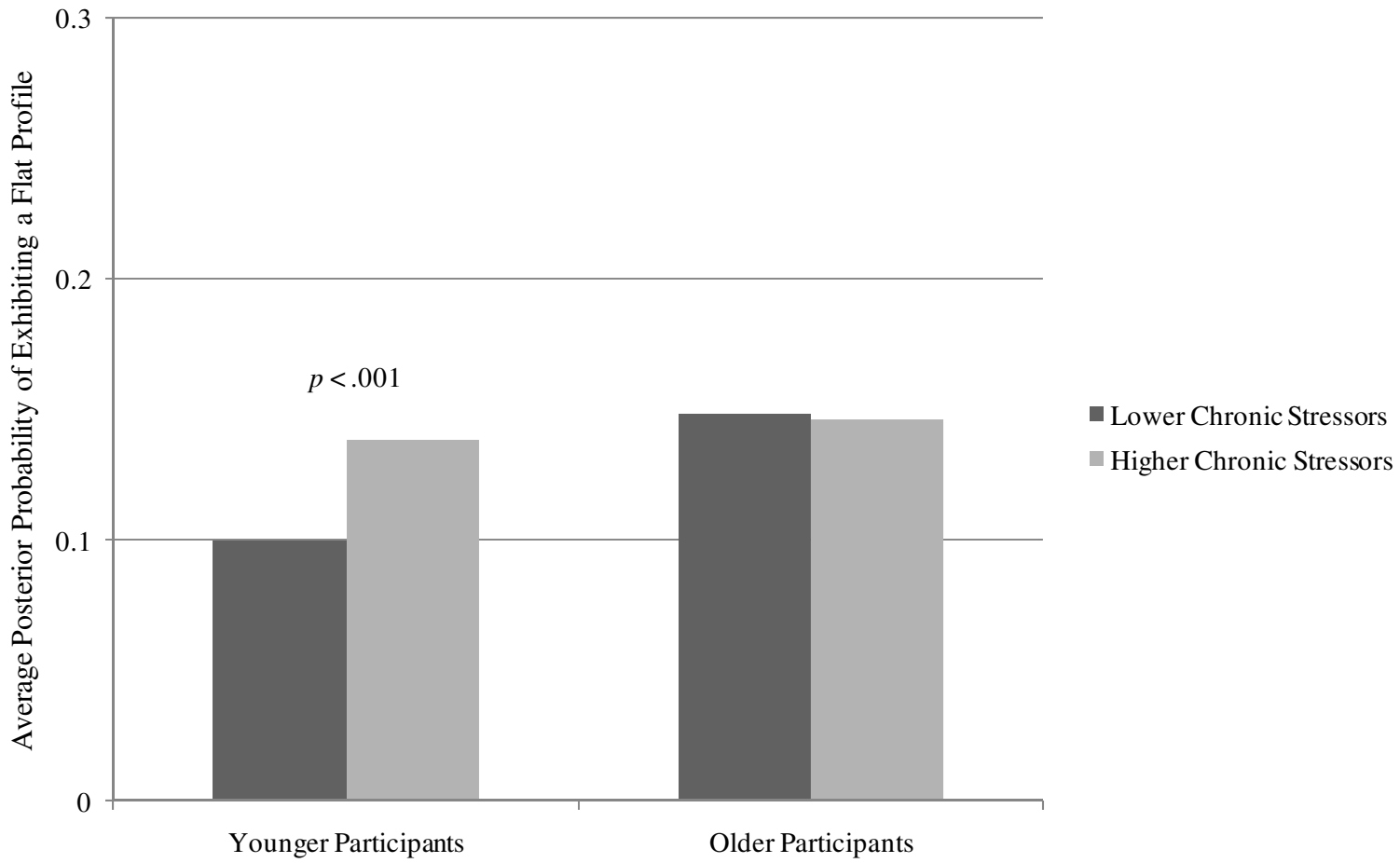

Figure 3.10. Average Posterior Probability of Exhibiting a Flat Profile: Age × Chronic Stressors.

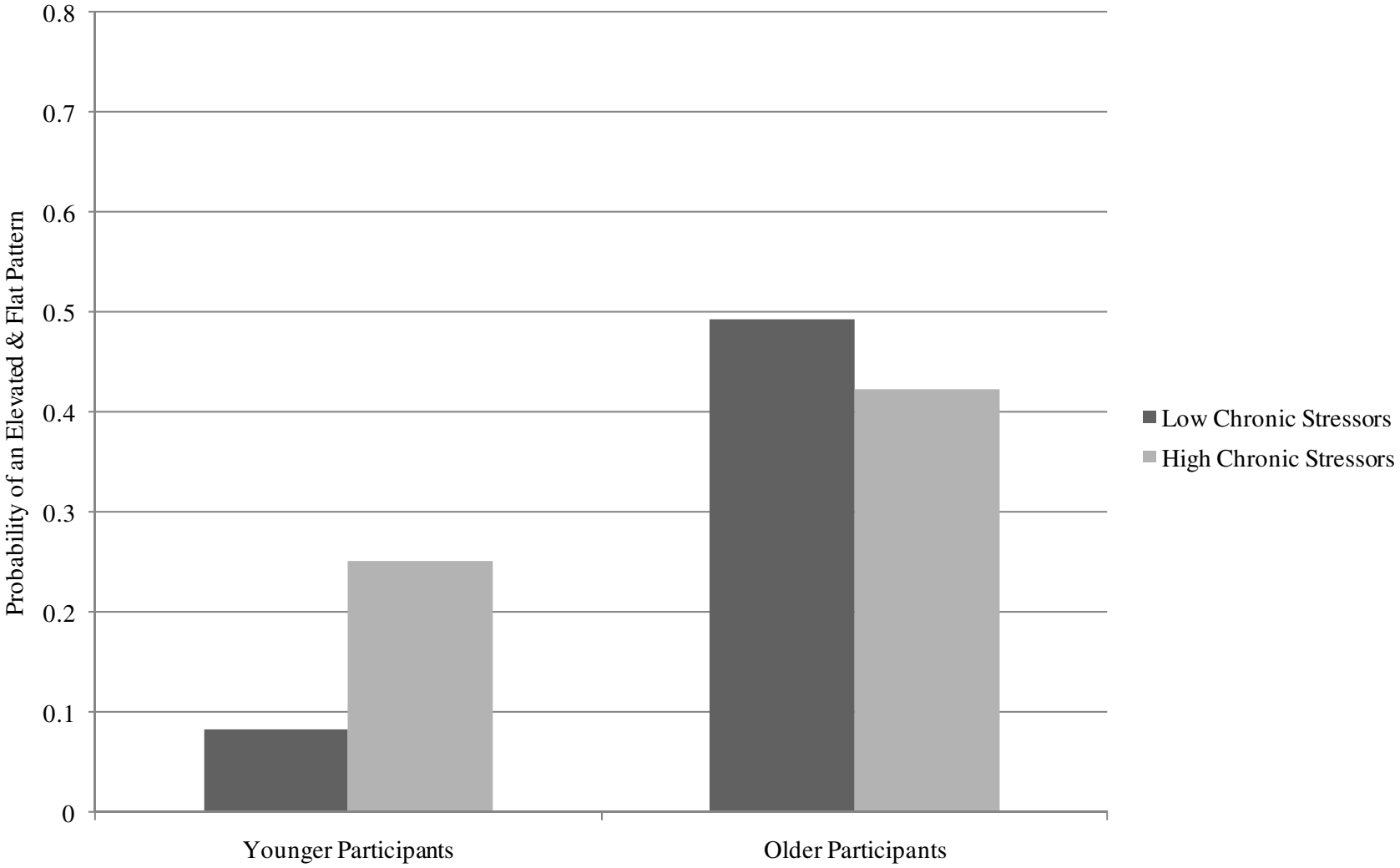

Figure 3.11. Probability of an Elevated and Flat Pattern: Age × Chronic Stressors.

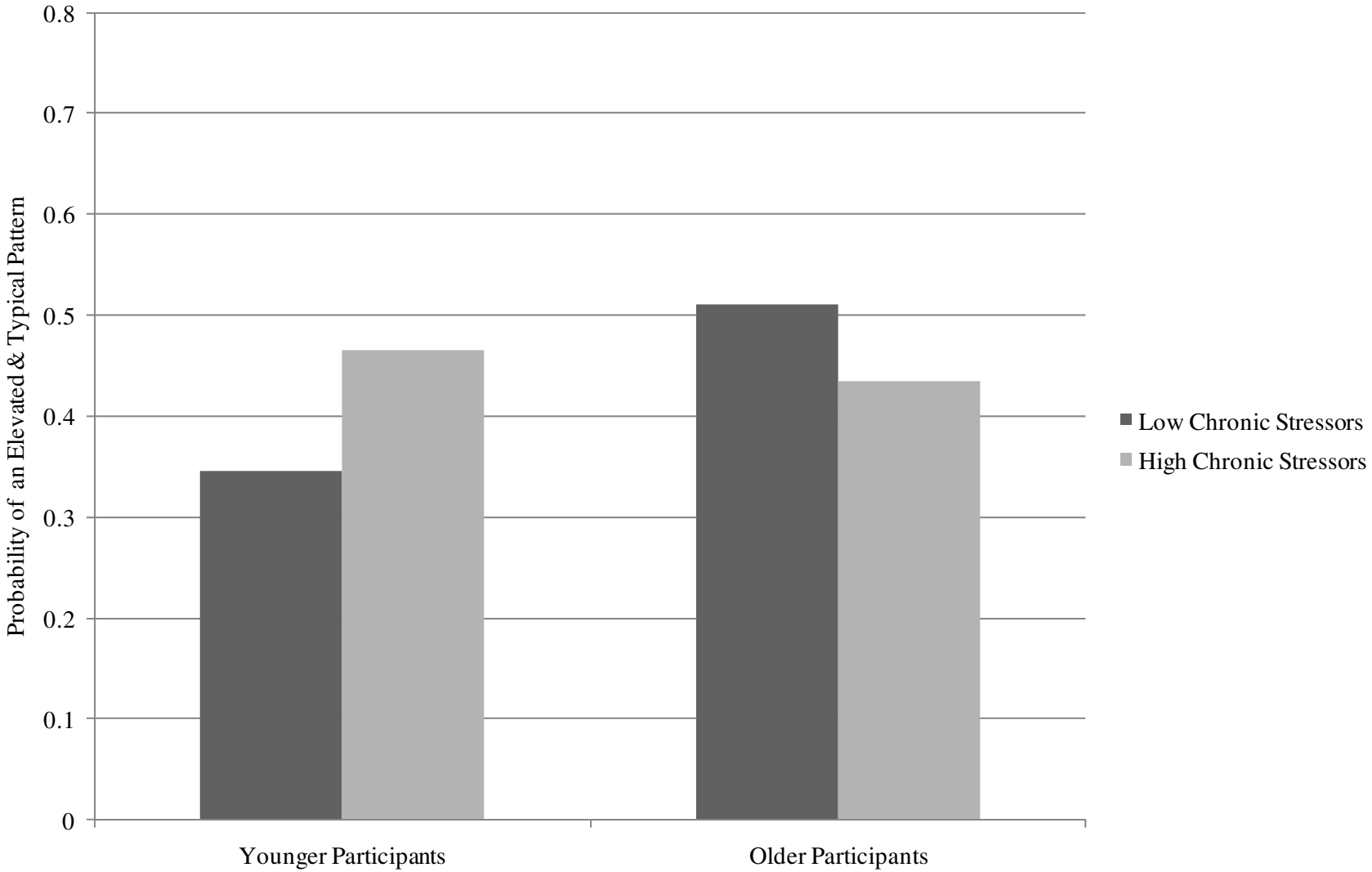

Figure 3.12. Probability of an Elevated and Typical Pattern: Age × Chronic Stressors.

CHAPTER 4: DISCUSSION

The current dissertation contributes to current literature on the hormone cortisol with a close exploration of the day-to-day functioning of the diurnal profile of this biomarker, along with cross-sectional analyses of the effects of age and stressors on this hormone. The overarching goals were threefold: 1) to explore and select person-centered profiles in diurnal cortisol, 2) to examine age differences in these profiles, and 3) to ascertain the role stressors play on the relation between age and diurnal cortisol. This section opens with a review of specific contribution of these analyses, followed by a section on more general implications, and closing with study strengths, limitations, and future directions for research.

Person-Centered Profiles of Diurnal Cortisol

Although previous work has examined links between factors predicting diurnal cortisol when operationalized as discreet or overall levels (e.g., Adam & Gunnar, 2001), or changes in level across the day (e.g., Ranjit et al., 2005), a limited number of studies have examined overall levels and form of diurnal cortisol, as these co-occur in the body (cf., Kumari et al., 2010; Lasikiewicz et al., 2008; Van Ryzin et al., 2009). The first set of analyses addressed a critical need in much of the current literature on diurnal cortisol: exploration and selection of typical person-centered patterns of diurnal cortisol and their day-to-day stability and variation, among a large sample of participants providing sufficient heterogeneity in diurnal cortisol. The best-fitting model–the 3-class solution estimated using GMM with latent time basis–indicated that the parameters of each of the three cortisol profiles evince striking stability across all study days.

Among participants providing at least one day of valid cortisol values, the majority exhibited a “typical” cortisol profile, characterized by the low awakening and bedtime levels, coupled with robust cortisol awakening response and diurnal slope. Depending on study day, the

actual proportion of participants showing this "typical" profile ranged between two-thirds and three-quarters (i.e., 64 to 75%) of the sample. The second most common profile appeared to be "elevated:" with waking cortisol level from 3.3 to 7.1 nmol/l higher than the waking level of individuals with a "typical" profile, with a blunted cortisol awakening response, and an diurnal slope that decelerated faster, ending in higher bedtime level than that of the "typical" profile. Model final class counts depicted that one-fifth to one-quarter (i.e., 18 to 28%) of participants exhibited this profile, depending on study day. The smallest class, which consisted of just under one-tenth (i.e., 7 to 9%) of respondents, exhibited a waking level similar to those of the "typical" class, but remained remarkably "flat" throughout the rest of the day, showing a minimal cortisol awakening response, and a weak diurnal slope.

Stability and Variability in Cortisol Profiles over Time

Descriptive analyses, based on respondents providing at least three days of valid cortisol data, showed that 43.2% of participants exhibited the "typical" profile across the entire study period. Thus, it appears that a large minority of individuals in midlife and older age always exhibit a typical diurnal cortisol profile, at least during a three-to-four day period of participating in a study consisting of eight consecutive evening telephone interviews. Exclusive stability in profile across days was uncommon within other profiles identified among this sample of participants, where only 0.6% and 3.0% of participants exclusively exhibited "flat" and "elevated" profiles, respectively. Individuals who typically show an "elevated" or a "flat" profile exclusively may be underrepresented in this sample, given that these individuals tended to be less healthy than other participants.

Even within the relatively short period of three to four days, some variability in cortisol profiles within participants was common among those respondents who did not always exhibit a

"typical" profile. The most common combination of profiles consisted of participants exhibiting both a "typical" and a "flat" profile during the study period (i.e., 32.9%). The remainder of profile combinations each consisted of less than ten percent of respondents, with 8.3% showing an "elevated" and a "typical" profile, and 8.1% exhibiting all three profiles during the study. Finally, 49 participants (4.0%) never exhibited a "typical" profile, showing both an "elevated" and a "typical" profile during the study.

Descriptive Analyses of Cortisol Profiles

Prior to accounting for relevant control variables, basic descriptive analyses of associations illustrated that participants with higher average posterior probability of exhibiting a "typical" profile and/or those always exhibiting the "typical" profile were younger, less likely to smoke cigarettes, were less likely to be an ethnic minority, reported better health, and were more likely to be employed. However, these direct associations also showed that this group of participants also had higher scores on a global measure of daily stressors, which was mostly driven by their tendency to report a greater number, rather than severity, of daily stressors. These participants, who were generally healthiest, also reported higher early life stress.

In contrast, both the "elevated" and "flat" profiles were generally associated with the opposite outcomes. Greater average posterior probability of exhibiting either an "elevated" or a "flat" profile was related to being older, being a minority, not being employed, and smoking cigarettes. A "flat" profile additionally appeared to be associated with poorer outcomes, such that a greater average posterior probability of exhibiting a "flat" profile was also related to poorer self-rated health. It is interesting that men had higher average posterior probabilities of a "flat" profile than women had. Further, those reporting lower global daily stressor score, driven by a lower number of daily stressors, also had a higher score on this measure of a "flat" profile.

Descriptive analyses of overall combinations of cortisol profiles showed that the pattern characterized by an absence of the "typical" profile was the least healthy. In other words, individuals exhibiting an "elevated and flat" pattern had the lowest self-rated health and a greater likelihood of smoking cigarettes. This group of participants was also older, more likely to be an ethnic minority, more likely to be female, less likely to be employed, and reported a lower number of daily stressors. The "always elevated" pattern was characterized by many of the same features, except for significant associations with gender and self-rated health. Unfortunately, due to a very small group size (i.e., 7), analyses predicting the "always flat" profile were impossible. However, mean differences indicated that this group of respondents was relatively older, and reported poorer self-rated health than participants in the "always typical" category did.

Given these descriptive results, as well as previous literature (e.g., Adam & Gunnar, 2001), the "typical" profile can be deemed as the healthiest among all three profiles. Further, showing a "typical" profile on at least some of the days is healthier than never showing this profile, as can be seen from poorer outcomes among individuals with "always elevated" and "elevated and flat" patterns during the study. Both the "elevated" and the "flat" profiles can be associated with older age, as shown is much of previous literature (e.g., Pruessner et al., 2005; Stawski et al., 2011). The "flat" profile, and instances when the "elevated" profile is exhibited in conjunction with the "flat" profile, were associated with poorer health.

The initially surprising findings of higher self-reported stress among participants with a greater average posterior probability of exhibiting a "typical" profile complement the literature showing that older adults report fewer stressors than adults in midlife or young adulthood (e.g., Almeida & Horn, 2004). Indeed, after accounting for control variables, the positive associations between stressors and "typical" profile were entirely attenuated.

Age Differences in Cortisol Profiles

Hierarchical linear and multinomial logistic regressions showed that after accounting for relevant control variables, the "typical" profile was associated with younger age. Participants with a higher average posterior probability of exhibiting a "typical" profile were younger, whereas greater average posterior probabilities of "elevated" or "flat" profiles were related to older age. Moreover, those who always showed the "typical" profile were significantly younger than those always showing an "elevated," both an "elevated" and a "typical" profile, and those who only experienced "elevated" and "flat" profiles, thus, never exhibiting a "typical" profile during the study period.

It is interesting to note that women had a higher average posterior probability of exhibiting a "typical" profile, whereas men had higher average posterior probability of exhibiting a "flat" profile, with no significant gender differences in an average posterior probability of exhibiting an "elevated" profile. There was no indication of significant age × gender interactions, although the direct effect of gender appeared to be partially mediated during examination of the moderating effect of stressors on the relation between age and diurnal cortisol in Aim 3.

Stressors Accelerate Age Differences in Cortisol Profiles

This study demonstrates that although there is variability in cortisol profiles among participants of all ages, stressors in earlier midlife appear to increase the likelihood of exhibiting profiles associated with older adulthood. Greater chronic stress among participants one standard deviation below average age (i.e., 44.5 year old respondents), had a lower average posterior probability of exhibiting a "typical" profile, so much so, that their average posterior probability of exhibiting a "typical" profile neared that of adults one standard deviation above average age in this sample (i.e., 68.7 year old respondents).

A decrease in the average posterior probability of exhibiting a "typical" profile among younger participants experiencing chronic stressors appeared to be coupled with an increase in the average posterior probability of exhibiting a "flat" profile. As in results predicting "typical" profile, chronically stressed younger participants exhibited average posterior probability of a "flat" profile that neared those of respondents who were nearly 25 years older.

Logistic regression analyses confirmed that chronic stress among younger participants significantly increases the likelihood of showing combinations of cortisol profiles that are associated with older age. When compared to younger participants reporting less chronic stress, younger participants with greater chronic stress were significantly more likely to exhibit the two non-"typical" profiles during the study (i.e., the "elevated and flat" pattern), than the "always typical" pattern. In addition, these younger participants with greater chronic stress were also more likely to experience the "elevated and typical" pattern, than the "always typical" pattern.

Unexpected Results

It is interesting to note that greater experience of life events produced the opposite moderating effect on the relation between age and diurnal cortisol profiles in some analyses. There were significant age × life events interactions on average posterior probabilities of a "typical" profile and an "elevated" profile. Tests of simple slopes showed that compared to younger respondents with low life event stress, younger participants with higher life event stress had a higher probability of exhibiting a "typical" profile. This was coupled with a reduction in posterior probability of exhibiting an "elevated" profile among younger participants with higher life event scores.

The fact that interaction between age and life events was not confirmed in multinomial logistic regression analyses of combinations of cortisol profiles, raised the possibility that this

finding may have resulted from issues of collinearity, which can result when multiple indicators and their interactions are introduced into a model. Additional tests with chronic and daily stressors excluded confirmed a lack of a significant interaction in predicting average posterior probabilities of exhibiting an "elevated" profile, although the effect predicting the "typical" profile remained significant at α=.05 level. Thus, it appears that greater life events among younger participants may be related to a "typical" profile according to one analysis.

The results of this dissertation supports work showing that diurnal cortisol assumes a hypocortisolic state after a passage of time following conditions of high chronic stress (e.g., Miller et al., 2007). The lack of an "elevated profile" in response to chronic stressors and life events can be understood in light of the fact that chronic stressors and life events were assessed, on average, almost 2 years prior to cortisol collection. Future studies testing immediate associations between stressors, age and diurnal cortisol may find somewhat different results from those presented here, given the different study design.

Another unexpected result was the lack of associations between cortisol profiles and daily stressors, despite the fact that these were collected within the same study period, unlike chronic stressors and life evens. This can be explained by a methodological inconsistency in using an aggregated score of daily stressors–a measure designed to assess stressors as daily phenomena–to predict day-to-day variability and stability in cortisol. In future research, it would be critical to analyze the day-to-day covariation in daily stressors and cortisol profiles.

General Contributions and Implications of Findings

Overall, there was remarkable similarity in profile parameters that participants exhibited on any given study day. As discussed briefly in *Results*, the findings were replicated when analyses were run on a randomly-selected cortisol participation day (i.e., rather than separately,

by day of saliva collection participation), as well as when they were assessed separately, within each gender. Given such a striking consistency, it is tempting to conclude that these cortisol profiles may be stable patterns that appear with relatively high reliability within any given day among any population of adults in middle and older adulthood. These three common patterns consist of the younger and healthier "typical" profile, the oldest and least healthy "flat" profile, and the "elevated" profile, which is similar to the "flat" profile, but perhaps predictive of fewer poor outcomes.

It is exciting to note the possible relevance of these findings to the foundational theoretical works on stress by Hans Selye and Bruce McEwen. In his description of the general adaptation syndrome, Selye (1956) proposes a general physiological response to an acute stressor, consisting of alarm, resistance and exhaustion, in order to explain how stressful situations lead to disease. The alarm reaction mobilizes the organism to respond, and culminates in the enlarging the adrenal cortex, the shrinking of thymicolymphatic system (consisting of thymus, spleen and lymphatic structures), and intestinal changes (e.g., appearance of deep duodenal and stomach ulcers). The stage of resistance is characterized by appearance of adaptation to the stressor, but a relatively low resistance to other stressors. The final and, ultimately, irreversible stage of the general adaptation syndrome is exhaustion: here the organism's adaptive reserves are depleted due to continual stress, causing irreparable wear and tear and eventually resulting in death.

Selye proposed each organism is allotted a finite amount of adaptational energy for its entire lifetime, which is depleted by stressors. As the organism continues encountering stressors, it often transitions through the first two stages of the general adaptation syndrome: alarm and resistance (Selye, 1976). However, a prolonged period of disproportionate stressor exposure

produces the long-term effect of stress observed under the stage of exhaustion: a premature depletion of adaptation energy.

The general adaptation syndrome does little in providing a framework for explaining how the body returns to stability post-stressor. According to Selye, some post-stressor recovery can occur through rest and sleep, but it is incomplete, such that stressful experiences leave "indelible scars" (Selye, 1979, p. 429). Bruce McEwen's (2001) proposal of allostasis (as previously discussed in *Introduction*), posits that the body achieves stability following stressors through an adaptive modification of cell structure and function. However, repeated exposure to stressors over the lifespan engenders wear-and-tear on the body, known as allostatic load. Cortisol has been conceptualized as a critical biological intermediary in this process, such that it is adaptive in small amounts, but produces excessive wear-and-tear under chronically high levels.

Although there are multiple ways that one can link the results of this dissertation to these classic models, one possible way is to introduce any day with a deviation from "typical" profile membership, or a low posterior probability of profile membership, as an indicator of alarm. A return to a typical profile indicates that although a stressor had perturbed the organism, but allostasis was achieved. An example of this would be a "flat and typical" pattern, or an "elevated, typical and flat" pattern. An indicator of increasing allostatic load – possibly indicative of a stage of resistance – would be evidence of increased probability of an "elevated" pattern, in light of no return to the "typical" profile, which signifies a return to homeostasis. These patterns would be related to an adaptation of diurnal cortisol to a stressor (i.e., increased likelihood of an "elevated" pattern), coupled with lower resistance to other stressors (i.e., increased likelihood of a "flat" pattern). The stage of exhaustion – an irreversible and late stage of general adaptation syndrome–is likely uncommon among individuals willing to participate in

an 8-day sub-study of a larger study, but may have been represented by the seven individuals exhibiting an "always flat" pattern.

Older age in this study was associated with a decreased posterior probability of a "typical" pattern, and an increased posterior probability of "elevated" and "flat" profiles. Older age was also related to a greater likelihood of an "always elevated" pattern and an "elevated and flat" pattern. Moreover, chronically stressed younger adults showed a lower posterior probability of "typical" pattern, and a higher average posterior probability of a "flat" pattern. Chronically stressed younger adults were also more likely to show an "elevated and flat" pattern, showing a pattern of cortisol that may be parallel to Selye's stage of resistance.

These results also support a recent meta-analysis of diurnal cortisol regulation in light of chronic stressors (Miller, Chen, & Zhou, 2007). In this meta-analysis, exposure to stressors was associated with a lower morning cortisol, higher afternoon/evening cortisol, and a flatter overall diurnal rhythm. Although this meta-analysis did not distinguish between awakening, 30-minutes after awakening, and morning cortisol levels in general, analyses showed that as time since stressor onset increased, the diurnal profile approaching that of the "flat" profile found in this dissertation emerged: decreasing morning cortisol decreases, coupled with high afternoon and evening cortisol levels. In this study, diurnal cortisol collected nearly two years following high report of chronic stressors, was also associated with a "flat" profile among younger participants.

According to one analysis, greater life events appear to be associated with a greater likelihood of exhibiting a "typical" profile among younger adults. If this result did not occur by chance, the effect of life events on cortisol appears to be age-specific, such that it is more likely to induce a "typical" profile among younger adults, but not among older adults. It is possible that experiencing serious adversity in childhood and throughout the lifespan may act as buffer to life

events later in life. Moreover, it is possible that the pervasive effects of life events induce allostasis earlier in midlife (i.e., McEwen), with their effects becoming more evident in older adulthood.

Strengths, Limitations and Future Directions

The key aims of the current dissertation were to identify typical patterns of diurnal cortisol, describe age differences associated with diurnal cortisol, and examine the moderating role of stressors on the relation between age and diurnal cortisol. A major strength of this dissertation is the opportunity to examine the research questions, including the short-term longitudinal variation in diurnal cortisol, among a national sample of English-speaking adults living in the United States. Another important contribution is the use latent basis GMM–a statistical approach that has rarely been used in cortisol literature (cf., Ram & Grimm, 2009), or in biobehavioral health literature in general (cf., Ventura, Loken, & Birch, 2009).

It is important to note several important limitations of this study. First, the significant results of the study need to be evaluated in light of the relatively small effect sizes. However, it is also important to keep in mind that data collection of cortisol occurred in the field, where participants collected saliva at home; this protocol may increase noise in data, increasing the standard error estimates. For example, many laboratory studies examining cortisol levels often ensure that participants are in a supine position when collecting awakening cortisol, and are seated when collecting other samples (R. Leproult, personal communication, November 11, 2009). Although participants were instructed to provide their waking saliva sample upon awakening, prior to getting out of bed in the morning, it is impossible to reduce increased error in this study resulting from factors such as posture. Further, controls for medication use, cigarette

smoking, and menopausal status were necessarily crude, given the available data. Future work should examine these factors in relation to cortisol profiles more closely.

The results of the study should also be extended by examining the hypotheses using a long-term longitudinal design. The findings are based on a cross-sectional design, and it is possible that differences in cortisol profiles existed prior to stressors, although the lag in time of collection of data on stressors and cortisol makes this conjecture less likely in the case of chronic and life event stress. In reference to study design, future work should also examine the relation between daily stressors and diurnal cortisol profiles on a daily level. This work should further distinguish between the effects of different types of stressors (e.g., a discrimination stressor vs. an overload work stressor) on diurnal cortisol.

Among the limitations, it is important to highlight that there are no clinical cut-offs for "healthy" diurnal cortisol levels or profiles. Thus, the outcomes in these analyses represented heterogeneity in cortisol profiles relative to the current sample, with no certainty of clinical implications. Further, the sample was relatively ethnically homogeneous, generally consisting of Caucasian participants. Future research should confirm the relationships found in this study within samples that are more ethnically diverse. Future work also should explore the consistency of cortisol profiles and their relationships age and stressors across the entire adult lifespan, by including younger adults, as well as adults in the oldest old age.

The focus of these analyses was on examination of common cortisol profiles in a population, outside of important known confounding factors. For example, it was important to exclude days where possible non-compliance (e.g., increases of more than 10 nmol/l from 30 minutes after awakening to bedtime values), or non-standard schedules (e.g., awakening prior to 0400) occurred. An examination of profiles among a population of night-workers, for example,

may result in identification of slightly different cortisol profiles, or in dissimilar proportion of individuals within each of the three profiles found in this study. A careful examination of the relation between cortisol profiles and physical health is needed. Future studies should also examine how cortisol profiles, as well as their stressor-associated differences with age, are related to psychological well-being before, during and after stressor onset.

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APPENDIX A: Tables Reviewing Selected Literature Related to Dissertation Aims

Table A-1

Aim 1: Selected Review of Diurnal Cortisol Patterns and Associated Outcomes

Study	Sample	Cortisol Collection	Main Results
Cortisol Medium: Urine			
Yehuda et al., 1990	16 male PTSD patients and 16 comparison (*M*=42 y.o.)	1 day 24 hr C collection	PTSD patients exhibit lower mean 24hr C than the comparison sample.
Yehuda et al., 1995	22 Holocaust survivors with PTSD, 25 Holocaust survivors without PTSD and 15 comparison participants (56-75 y.o.; 55% female)	1 day 24 hr C collection	Holocaust survivors with PTSD exhibit lower mean 24hr cortisol than the comparison sample or the sample of Holocaust survivors without PTSD.
Luecken et al., 1997	109 women (*M*=33 y.o.) employed in clerical and customer service jobs at a large corporation	2 days of C collection (overnight, work hours, evening periods)	Higher C during the 24hr period is associated with having at least one child living at home and with higher perceived home stress (but not perceived work stress) among employed women. Null results within time of day.
Kario et al., 2002	134 women (*M*=34 y.o.) employed at managerial, technical or clerical jobs at a medical center in NYC	1 day of C collection (overnight, work hours, evening period)	No differences in C when women who find work more stressful than home are compared to women who find home more stressful than work.
Dowd & Goldman, 2006	972 participants from Social and Environmental Biomarkers of Aging Study (54+ y.o.)	1 day of C collection (12hr overnight)	No education or income differences in overnight C among men. Lower overnight C among women who are less educated (null results for income).
Cortisol Medium: Blood			
Caplan et al., 1979	200 male NASA administrators, engineers and scientists (*M*=40 y.o.)	1 time plasma C collection (between 900 and 1600)	Employees experiencing high perceived work load have lower morning C levels and higher afternoon C than employees experiencing low perceived work load. (Employees were grouped and compared according to time of day when C was sampled).
Cortisol Medium: Saliva			

Smyth et al., 1997	109 participants (*M*=36 y.o.; 71% female)	2 days of C collection (every 2hrs, from 800 to 2200hrs)	3 C profiles (using cutoffs for regression estimates) were identified: Normal Cycle with steeper than -0.05 mean negative slope in log-C throughout day (51%), Inconsistent Cycle (31%), and Flat Cycle with flatter than -0.05 mean negative slope in log-C (17%; associated with fewer upper respiratory symptoms). No associations with age, gender, perceived stress and all other demographic and psychosocial measures.
Adam & Gunnar, 2001	79 mothers of toddlers (*M*=34 y.o.)	2 days of C collection (waking, 1400, 1500, 1600, 1700, bedtime)	Having a younger toddler is associated with lower awakening C value, flatter DD, and higher evening C. Working a greater number of hours is associated with lower awakening C and a trend for flatter DD. Mothers with greater number of children, and mothers who were more secure in relationship functioning have higher awakening C and steeper DD (due to high awake values). Older mothers have higher average C.
Ice et al., 2004	48 community-dwelling participants (*M*=79 y.o.; 65+ y.o.; 70% female)	2 days of C collection (every 2hrs, from 800 to 2200hrs)	3 C profiles (using cutoffs for regression estimates) were identified: Normal Cycle with steeper than -0.05 mean negative slope in log-C (50%; associated with older age, when compared to Inconsistent Cycle), Inconsistent Cycle (48%; associated with younger age, frequent caffeine intake, food intake prior to C collection) and Flat Cycle with flatter than -0.05 mean negative slope in log-C (2%). No associations with demographic characteristics, stressful life events, and perceived stress.
Kurina et al., 2004	91 dual-earners (27-57 y.o.; 63% female), subset of the 500 Families Study	2 workdays of C collection (waking, 20 minutes after each beep, bedtime)	Among women, perception of work as often or always stressful is associated with lower average C (interpreted as a false positive, due to a high number of statistical tests performed). Among men, experiencing more frequent anxiety symptoms is associated with higher average C. Null results for slope across the entire day.
Ranjit et al., 2005	188 low-income single mothers from Women's Employment Study (*M*=34 y.o.; 18-54 y.o.)	1 days of C collection (0 and 30min after awakening, and before bedtime)	Women with greater material hardship exhibit flatter CAR and DD than women with lower material hardship.

Yehuda et al., 2005	23 Holocaust survivors with PTSD (*M*=69 y.o.), 19 Holocaust survivors without PTSD (*M*=69 y.o.), and 25 comparison participants (*M*=74 y.o.) (51% female)	1 day of C (waking, 800, 1200, 1600, 2000, before bedtime)	Compared to the other 2 subsamples, Holocaust survivors with PTSD have flatter C rhythm: lower waking and 800 C levels, and higher 2000 C levels.
Eller et al., 2006	87 participants (*M*=47 y.o. among women and 49 y.o. among men; 63% women)	1 day of C collection (0, 20, 30, 60min, 8hrs after awakening, at 1800)	Among women, greater time pressure, effort, and effort-reward imbalance are associated with higher average C. Women feeling greater time pressure also exhibit higher CAR. Among men, greater effort, effort-reward imbalance and overcommittment are associated with higher average C and higher CAR. Men feeling greater time pressure exhibit higher awakening C. Null results for work demands and control.
Hoppmann & Klumb, 2007	53 employed couples (*M*=37 y.o.)	6 days of C collection (waking, every 3 hours from 930 to 2100)	When compared to engagement in activities that further (or are unrelated to) one's work and family goals, engagement in activities that hinder one's work or family goals is associated with higher concurrent C levels.
Miller et al., 2007	Meta-analysis of 107 independent studies; 8,521 participants (*M*=38 y.o.; 47% female)	Morning cortisol, total cortisol output, afternoon/evening cortisol.	Exposure to stressors is related to lower morning C, higher afternoon/evening C, and a flatter overall rhythm. Further, current stressor experience is associated with higher morning and afternoon/evening C. When stressor is no longer present, morning C decreases and afternoon/evening C increases.
Rohleder et al., 2007 (Study 1)	44 competitive dancers (17-62 y.o.; 50% female)	2 days of C (competition and non-comp. days; 0 and 30min after waking, 2hr intervals thereafter, before, during after competition)	Greater overall C on competition than on non-competition days.

Bergman et al., 2008	40 academic physicians (*M*=47 y.o.; 43% female)	1 day of C collection (0 and 30min after waking, before dinner, at 2000)	Higher responsibility at home is associated with higher evening C (no effect of gender).
Lasikiewicz et al., 2008	147 participants (*M*=46 y.o.; 54% female); participants were combined from 2 studies	1-3 days of C collection (0, 15, 30, 45min after waking, 3, 6, 9, 12hrs after waking)	2 C profiles (using *K*-means cluster analysis) were extracted: blunted CAR/blunted DD/low AUC group (78% of sample; associated with greater insulin resistance, waist-hip ratio, poorer sleep quality) and typical group (22% of sample). No associations with age, gender or perceived stress.
Saxbe et al., 2008	30 employed couples (median age: 31 y.o.)	1 day of C collection (waking, and before lunch, leaving work, and bedtime)	Among participants of both genders, evening C is higher on higher-workload days. Among women, lower marital satisfaction is associated with lower awakening C level and flatter DD in general.
Miller et al., 2009	53 participants low in early life SES (*M*=34 y.o.; 62% female) matched with 50 participants high in early life SES (*M*=32 y.o.; 58% female); participants had identical current SES	3 days of C collection, 6 times per day	Compared to participants with high early-life SES, participants with low early-life SES have greater overall daily C, but do not differ on CAR and DD.
O'Connor et al., 2009	118 women with low and high perceived stress (*M*=49 y.o.; 40-60 y.o.)	2 days of C collection (0, 15, 30, 45min after waking, 3, 6, 9, 12hrs after waking)	When compared to women with low perceived stress, women with higher perceived stress secrete lower total C from waking to 45mins after waking (largely due to lower 30min value), and higher total C from 3 to 12hrs after waking.
Seltzer et al., 2009	82 parents of child with disability (*M*=57 y.o.; 58% female) compared with 82 parents of child without disability (*M*=57 y.o. 58% female) (NSDE subsample)	4 days of C collection (0 and 30min after awakening, before lunch and bedtime)	Compared to parents of child without disabilities, parents of child with disabilities exhibit flatter DD in general, an exhibit flatter DD on days they spend more time with their child. Gender effect not tested.

Kumari et al., 2010	2801 Whitehall II participants (*M*=61 y.o.; 23% female)	1 day of C collection (0 and 30min after waking, 2.5, 8, 12hrs after waking, before bedtime)	2 C profiles (using Latent Variable Mixture Modeling) were identified: high CAR/blunted DD (27% of sample; associated with older age (trend), being male, smoking, a more severe stressor on day of sampling, slower walking speed, shorter sleep) and typical group (73% of sample).
Seltzer et al., 2010	86 mothers of child with autism spectrum disorder (ASD, *M*=54 y.o.) matched with 171 mothers (NSDE subsample) of child without a disability (*M*=50 y.o.)	4 days of C collection (0 and 30min after awakening, before lunch and bedtime)	Flatter CAR following days of greater behavior problems (on the part of the child) among mothers of child with clinically-significant levels of behavior problems, when compared to mothers of child with below-clinical levels of behavior problems. When compared to mothers in the comparison sample, mothers of child with ASD exhibited lower C values at each individual time point.
Dowd et al., 2011	311 participants from Chicago Community Adult Health Study (18-70 y.o.; 57% female)	2 weekdays of C collection (0, 30min after waking, before dinner, before bedtime)	Attaining less than a H.S. education is related to lower waking C, and lower total C levels. Null results for DD.
Stawski et al., 2011	1,645 (M=57 y.o.; 56% female) (NSDE participants)	4 days of C collection (0 and 30min after awakening, before lunch and bedtime)	When compared to daily stressor-free days, days with 1 or more stressors are associated with higher C AUC. This appears to be driven by arguments and overloads at home, but not avoided arguments or overloads at work. The effect of stressors was partially, but not completely mediated by negative affect.

Note. Articles are arranged chronologically, within appropriate section on cortisol media. To conserve space, "C" represents "cortisol."

Table A-2

Aim 2: Selected Review of Link between Age and Diurnal Cortisol Patterns

Study	Sample	Cortisol Collection	Main Results
Cortisol Medium: Urine			
Yehuda et al., 2007	10 year follow-up of 28 Holocaust survivors (60% female; at T2: PTSD+ *M*=76 y.o., PTSD□ *M*=79 y.o.)	1 day 24 hr C collection.	Participants: 3 remitted PTSD, 3 developed PTSD, 14 consistent PTSD+, 8 consistent PTSD□. C increased among survivors with remitted PTSD, declined among survivors who developed PTSD, or were stable PTSD+ or PTSD□.
Cortisol Medium: Blood			
Lupien et al., 1996	31 participants (60-87 y.o. at baseline; 33% female)	Annual collection of 24hr plasma C for 3 to 6 yrs	Three longitudinal patterns of change in integrated 24hr C over time emerged: Increasing/Currently High Group (23%; also, group with significant cognitive impairments), Increasing/Currently Moderate (57%), Decreasing/Currently Moderate (20%). No cross-sectional age associations with C. No gender differences in C change.
Van Cauter et al., 1996	177 participants (*M*=40 y.o.; 49% female) (combined sample from 7 groups of investigators)	1 day of plasma C collection (24hr, intervals not exceeding 30min)	Older age is associated with higher mean C level, higher C nadir, earlier nadir, Among women: older age is associated with higher C acrophase, more pronounced age-related increases in mean C level.
Deuschle et al., 1997	11 women (*M*=48 y.o.; 24-81 y.o.) 22 men (*M*=53 y.o.; 23-85 y.o.)	1 day of plasma C collection (24hr, intervals 10 to 30min)	Older age is associated with higher mean C level, higher C nadir.
Cortisol Medium: Saliva			
Adam & Gunnar, 2001	79 mothers of toddlers (*M*=34 y.o.; 24-42 y.o.)	2 days of C collection (waking, 1400, 1500, 1600, 1700, bedtime)	Older mothers have higher average C.
Brandtstadter et al., 1991	767 participants (subsample of study on married couples, 35-65 y.o.)	Early morning (700-900), afternoon (1500-1700), evening (200-2200)	Older age is associated with lower morning C value among women, but not men. Null results for evening C levels.

Smyth et al., 1997	109 participants (*M*=36 y.o.; 71% female)	2 days of C collection (every 2hrs, from 800 to 2200hrs)	3 C profiles (using cutoffs for regression estimates) were identified: Normal Cycle with steeper than -0.05 mean negative slope in log-C throughout day (51%), Inconsistent Cycle (31%), and Flat Cycle with flatter than -0.05 mean negative slope in log-C (17%; associated with fewer upper respiratory symptoms). No associations with age, gender, perceived stress and all other demographic and psychosocial measures.
Raff et al., 1999	228 older (*M*=70 y.o.; 43% female) and 73 younger (*M*=37 y.o.; 52% female) participants	1 day of C collection (2300 and 700 on following morning)	Older adults exhibited elevated evening C compared to young adults. No age differences in morning level.
Adam & Gunnar, 2001	79 mothers of toddlers (*M*=34 y.o.; 24-42 y.o.)	2 days of C collection (waking, 1400, 1500, 1600, 1700, bedtime)	Older mothers have higher average C.
Ice et al., 2004	48 community-dwelling participants (*M*=79 y.o.; 65+ y.o.; 70% female)	2-3 days of C collection (every 2hrs, from 800 to 2200hrs)	3 C profiles (using cutoffs for regression estimates) were identified: Normal Cycle with steeper than -0.05 mean negative slope in log-C throughout day (50%; associated with older age, when compared to Inconsistent Cycle), Inconsistent Cycle (48%; associated with younger age, frequent caffeine intake, food intake prior to C collection), and Flat Cycle with flatter than -0.05 mean negative slope in log-C (2%). No associations with demographic characteristics, stressful life events, and perceived stress.
Pruessner et al., 2005	16 young (20-26 y.o.) and 23 older (60-84 y.o.) participants	1 day of C collection (0 and 30min after waking, 1400, 1600, before bedtime)	Older adults exhibit a slightly flatter CAR.
Ranjit, Young, Raghunathan, et al., 2005	188 low-income single mothers from Women's Employment Study (*M*=34 y.o.; 18-54 y.o.)	1 days of C collection (0 and 30min after awakening, and before bedtime)	Older low-income women exhibit lower average C, such that average C level decreases by 0.049 μg/dl for each additional year.

Rohleder et al., 2007 (Study 3, part 2)	44 competitive dancers (17-62 y.o.; 50% female)	1 day of C (on competition day; 2 hour intervals, before start of competition, between competition rounds)	No age difference on C during competition day.
Lasikiewicz et al., 2008	147 participants (*M*=46 y.o.; 54% female) (participants were combined from 2 studies)	1-3 days of C collection (0, 15, 30, 45min after waking, 3, 6, 9, 12hrs after waking)	2 C profiles (using *K*-means cluster analysis) were extracted: blunted CAR/blunted DD/low AUC group (78%; associated with greater insulin resistance, waist-hip ratio, poorer sleep quality) and typical group (22%). No associations with age, gender or perceived stress.
Almeida et al., 2009	1,143 (*M*=57 y.o.; 33-84 y.o.; 55% female) (subsample of NSDE)	4 days of C collection (0 and 30min after awakening, before lunch and bedtime)	Older age is associated with greater CAR, but only among men. Older age is associated with greater day-to-day variability in CAR, but only among men.
O'Connor et al., 2009	118 women with low and high perceived stress (*M*=49 y.o.; 40-60 y.o.)	2 days of C collection (0, 15, 30, 45min after waking, 3, 6, 9, 12hrs after waking)	Trend for age with greater total C secretion from waking to 45min after waking (p=.059). No effect of age total C secretion in the second part of the day.
Kumari et al., 2010	2801 Whitehall II participants (*M*=61 y.o.; 23% female)	1 day of C collection (0 and 30min after waking, 2.5, 8, 12hrs after waking, before bedtime)	2 C profiles (using Latent Variable Mixture Modeling) were identified: high CAR/blunted DD (27%; associated with older age (trend), being male, smoking, a more severe stressor on day of sampling, slower walking speed, shorter sleep) and typical group (73%).

Note. Articles are arranged chronologically, within appropriate section on cortisol media. To conserve space, "C" represents "cortisol."

Table A-3

Aim 3: Selected Review of Stressors Moderating Link between Age and Diurnal Cortisol Patterns

Study	Sample	Cortisol Collection	Main Results
Cortisol Medium: Urine			
Schnorpfeil et al., 2003	324 employees of an airplane manufacturing plant (*M*=41 y.o.; 21-61 y.o.; 16% female)	Allostatic load; one component was 1 workday of C collection (9pm to first void after waking)	Higher job demands are associated with greater allostatic load, but only among middle-aged and older employees. There was no significant effect of job demands on allostatic load among adults under the age of 30 y.o.
Cortisol Medium: Blood			
Ritvanen et al., 2006	14 younger (*M*=31) and 14 older (*M*=54) female teachers	2 days of single plasma C collection (a day during high- and low-stress periods) (post 12hr fast; between 800 and 900)	When compared to low-stress periods, high-stress periods elicit higher C among younger teachers. Conversely, older teachers exhibit high C regardless of high or low stress. Unlike younger adults, older teachers did not experience a drop in heart rate (or C) during low-stress periods, and did not exhibit a decrease in blood pressure in the evening following work.
Cortisol Medium: Saliva			
Rohleder et al., 2007 (Study 3, part 2)	44 competitive dancers (17-62 y.o.; 50% female)	1 day of C (on competition day; 2 hour intervals, before start of competition, between competition rounds)	No age difference or age interaction with length of competition experience on C during competition day.
Varadhan et al., 2008	214 women from Women's Health and Aging Study (80-89 y.o.)	1 day of C (900, 930, 3 times between lab evaluation tasks, before bedtime, and within 30min after waking next morning)	Condition of frailty among older women is associated with flatter C decline throughout the day, higher evening C, higher 24hr mean C. Authors interpret that frailty appears to be accelerate the aging of diurnal C profile.

Note. Articles are arranged chronologically, within appropriate section on cortisol media. To conserve space, "C" represents "cortisol."

APPENDIX B: NSDE Wave 2 Saliva Collection Protocol

Description

In the second wave of NSDE, participants are asked to provide four saliva samples on days 2 through 5 in addition to completing short telephone interviews about their daily experiences across eight consecutive days. Saliva samples are collected at waking (before getting out of bed), 30 minutes after getting out of bed, before lunch, and before bed. Participants are instructed to collect samples before eating, drinking, or brushing their teeth. In addition, participants are asked not to consume any caffeinated products (e.g., coffee, tea, soda, or chocolate) before collecting samples. Data on the exact time respondents provide each saliva sample is obtained from the nightly telephone interviews and from a paper-pencil log sent with the collection kit. Prescription and over-the-counter medications taken during the collection period are recorded during the telephone interview of the last day of saliva collection. In addition, a group of respondents receive a "Smart Box" to store their salivettes. These boxes contain a computer chip that records the time respondents open and close the box.

When all 16 tubes are ready to be sent, participants use a pre-addressed, paid courier package for the return mailing. The enclosed salivettes are shipped to the MIDUS Biological Core at the University of Wisconsin, where they are stored in an ultracold freezer at -60^{o} C. For analysis, the salivettes are thawed and centrifuged at 3000 rpm for 5 minutes, yielding a clear fluid with low viscosity. Cortisol concentrations are quantified with a commercially available luminescence immunoassay (IBL, Hamburg, Germany), with intra-assay and inter-assay coefficients of variation below 5%.

Of the 2,022 respondents (RDD, Twin, Sibling, City Oversample, and Milwaukee) who have completed wave 2 of the NSDE, 1,736 (85.9%) provided saliva samples.

Saliva and Cortisol Variables

In addition to the saliva and cortisol information described below, saliva and cortisol variables are also outlined in M2_P2_Daily Data Measurement Instrument_7-14-09.pdf.

A. The first set of saliva- and cortisol-related variables allows for a descriptive examination of the saliva and cortisol data.

B2DCORT: denotes whether a participant provided any saliva samples (1=*yes*, 2=*no*). Additionally, a value of 3 is denoted if a participant said they provided saliva but no samples were received. This is a between-person variable.

B2DCDAY: denotes at least one valid cortisol sample on a given day for participants who provided saliva (1=*yes*, 2=*no*, 8=*refused/missing*). This is a daily variable.

B2DSMART: denotes whether a participant provided "Smart Box" data (1=*yes*, 2=*no*). Refused or missing responses are denoted as 8. This is a between-person variable.

B2DCWDAY: denotes whether a participant provided saliva samples outside of the designated saliva collection days 2 through 5 (1=*yes*, 2=*no*, 8=*refused/missing*). For example, a participant

could have started saliva collection on day 1, rather than day 2, and ended collection on day 4, rather than day 5. This is a between-person variable.

B. Raw Cortisol Values

The raw cortisol values for the four occasions are represented by B2DCORW (cortisol at waking), B2DCORA (30 minutes after waking), B2DCORL (before lunch), and B2DCORB (before bed). Cortisol values are in nanomoles per liter (nmol/l). No boundary restrictions are placed on the cortisol values, such that values as low as .00020 nmol/l and as high as 201241.60829 nmol/l are observed in the data.

In addition to actual raw values, the following values denote some type of non-response.

999994. UNRELIABLE
999995. NOT DONE
999996. EMPTY
999998. REFUSED/MISSING

Unreliable includes zero and unreliable values. Not done means the sample is missing. Empty reflects that a sample is sent to the lab, it is spun down, and there is little or no saliva in the bottom of the tube.

C. Cortisol Collection Time Values

Sources of Data:

The following variables represent the timing of saliva samples: B2DCORWT (at waking), B2DCORAT (30 minutes after waking), B2DCORLT (before lunch), and B2DCORBT (before dinner). Participants provide two sources of information on the timing of saliva samples: 1) paper-pencil log, as completed by the participant, and 2) interview saliva collection times, as obtained by the interviewer from the participant during the telephone interview. Participants fill out the appropriate time for each saliva collection sample on the paper-pencil log and mail it along with their completed saliva samples. In addition, the interviewer records each cortisol collection time during interview days when saliva collection occurs.

The paper-pencil log is the primary source of data for saliva collection times. Interviewer-obtained saliva collection time is a secondary source information, which is used to supplement paper-pencil log cortisol collection time. Specifically, participant-provided paper-pencil log times are first used to create B2DCORWT, B2DCORAT, B2DCORLT, and B2DCORBT variables. The interviewer-obtained saliva collection times are entered in, in cases when one or more paper-pencil log cortisol collection times are not available.

Construction of Variables:

Saliva collection time variables (B2DCORWT, B2DCORAT, B2DCORLT, and B2DCORBT) appear in 24-hour military time. The dataset is organized according to interview day, therefore,

formatting the 4 saliva collection times in military time achieves the goal of giving a successive order to the timing of the samples over each interview day (e.g., "6.00" at B2DCORWT, "6.50" at B2DCORAT, "12.00" at B2DCORLT, and "22.00" at B2DCORBT).

Data cleaning process revealed that on some days, participants report collecting saliva samples particularly early (i.e., prior to the beginning of interview day) or particularly late (i.e., after the end of interview day). Therefore, saliva collection time values appear outside of 0-to-24 hour range in these cases. In order to keep all saliva collection times in successive order within each interview day, we decided to subtract "24.00" in cases where saliva collection occurred on the day prior to interview day, and add "24.00" in cases where saliva collection occurred on the day after the interview day. For example, an early awakening time of 11pm on a previous interview day resulted in B2DCORWT value of "–1.00". Similarly, a relatively late bedtime of 2am resulted in B2DCORBT value of "26.00."

Cortisol Collection Time Variables:

B2DCORWT: CORTISOL COLLECTION TIME AT WAKING

B2DCORAT: CORTISOL COLLECTION TIME 30 MINUTES AFTER WAKING

B2DCORLT: CORTISOL COLLECTION TIME BEFORE LUNCH

B2DCORBT: CORTISOL COLLECTION TIME BEFORE BED

98. REFUSED/MISSING

D. Medication Use During Saliva Collection

Information on use of over-the-counter and prescription medications relevant to cortisol level is obtained on the last day of saliva collection. Participants endorse use of seven types of medication (see below) with a 1 (*yes*) or 2 (*no*) response. Typically, these questions are administered on interview day 5 of the NSDE interview, unless the participant finishes saliva collection early (e.g., interview day 4) or late (e.g., interview day 6). In cases where participants report no medication use for any of the categories, B2DMED10 is recoded into a 1 (*yes*) category.

Medication Use Variables:

During the days you provided saliva, did use you use any of the following medications?

B2DMED1: OVER THE COUNTER OR PRESCRIPTION ALLERGY MEDICATIONS (E.G., BENADRYL, FLONASE, OTC SLEEP MEDICATIONS)

B2DMED2: A STEROID INHALER (E.G., ADVAIR, FLOVENT, PULMICORT)

B2DMED3: OTHER STEROID MEDICATION
(E.G., PREDNISONE, TRIAMCINOLONE)

B2DMED4: MEDICATIONS OR CREAMS CONTAINING CORTISONE
(E.G., CORTAID, CORTIZONE, DIPROSONE, PSORCON)

B2DMED5: BIRTH CONTROL PILLS

B2DMED6: OTHER HORMONAL MEDICATIONS
(E.G., ESTRATEST, LEVOTHYROXINE, PREMPRO, SYNTHROID)

B2DMED7: ANTI-DEPRESSANTS OR ANTI-ANXIETY MEDICATIONS
(E.G., CELEXA, EFFEXOR, PAXIL, VALIUM, WELLBUTRIN)

B2DMED8: DON'T KNOW
B2DMED9: REFUSED
B2DMED10: NONE

1. YES
2. NO
7. DON'T KNOW
8. REFUSED/MISSING
9. INAPPLICABLE

APPENDIX C: Documentation of Stress Summary Measures for MIDUS 2 and Milwaukee Surveys

Introduction

The following document describes the methods that we used to create summary stress scores for the Midus 2 and Milwaukee surveys. The goal of this work was to develop measures that reflect the accumulation of stress from multiple sources. These measures can be used to predict behavioral, biological, and health outcomes from Project 1 through 5. We developed 11 domains of stress, and one overall summary measure that incorporates all 11 stress summary scores. Each stress domain is comprised of one or more psychosocial measures that capture a dimension of the form of stress being measured (see Page 3 for complete list).

Contact David Williams (dwilliam@hsph.harvard.edu) or Natalie Slopen (nslopen@hsph.harvard.edu) with questions

Components of 10 Stress Domains

1. **Psychological Work Stress** (details on Page 6)
   a. Skill Discretion
   b. Decision Authority
   c. Demands Scale
   d. Coworker Support (reverse coded)
   e. Supervisor Support (reverse coded)

2. **Physical Work Stress** (details on Page 7)
   a. Physical Strain
   b. Risk of Injury on the Job

3. **Work-family Spillover** (details on Page 8)
   a. Negative Work-to-Family Spillover
   b. Negative Family-to-Work Spillover

4. **Perceived Inequality** (details on Page 9)
   a. Perceived inequality in family
   b. Perceived inequality in home
   c. Perceived inequality in work

5. **Relationship Stress** (details on Page 10)
   a. Family Strain
   b. Friend Strain
   c. Marital Risk Scale
   d. Spouse/Partner Strain Scale

6. **Neighborhood Stress** (details on Page 11)
   a. Personal Beliefs on Neighborhood (reverse coded)

7. **Discrimination** (details on Page 12)
   a. Lifetime Discrimination
   b. Daily Discrimination
   c. Job Discrimination

8. **Financial Stress** (details on Page 13)
   a. Financial Stress Scale

9. **Past Year Problems in Immediate Family** (details on Page 14)
   a. Problems for Spouse/Partner
   b. Problems for Parents
   c. Problems for Children

10. **Stressful Life Experiences** (details on Page 15)
    a. Past 5 Years
    b. Lifetime (excluding child-specific stressors)

11. **Early Stress Experiences** (details on Page 16)
    a. Child Stress Events
    b. Relationship with Parents
    c. Verbal or Physical Abuse by Parents

12. **Overall Summary Score** (details on Page 17)

Description of each stress measure includes: the list of items making up the scale, information about scoring, variable names from the original data, and Chronbach's alphas for the Midus and Milwaukee samples (if applicable).

Note:
It is critical that all individuals who utilize these variables read these notes in order to understand how the variables were created and any limitations of the specific measure, or required covariates for a given stress measure.

Analysis Using Stress Measures

There are some stressors that an individual may be ineligible to experience, based on the circumstances of his or her life. For example, an individual who is not employed will not have a valid response to the work stress measures, just as an individual who is not married/partnered will not have a valid response on the measures of spouse/partner strain. For individuals with missing information, we utilized demographic information to determine whether each individual was eligible for the specific stress measure; if the respondent was not eligible, the respondent was given the lowest possible value on this stress measure. As a result, for certain stress measures, it is essential to control for the variable used to determine the substitution (e.g., marital/partner status, current employment status, 1+ child). Table 1 on Page 5 indicates the control variables that, if any, are necessary for each stress summary measure. We describe the creation of each stress measure (including substitution of lowest value for those with missing information if they are not eligible for the stressor) in Pages 6 through 17 of this document.

Description of Imputation

Many of the stress measures that we have used in the stress summary scores were collected in the SAQ (this is particularly true for the Midus 2 respondents). Unfortunately, for some measures, there is a large amount of missing information exists (see Table 3 on Page 19 for description); therefore, we decided to impute missing information in order to avoid having to exclude these participants from the sample. To perform the imputation, we used IVEware software to carry out the sequential regression imputation method developed by Rhagunathan (2001). This method fits a sequence of regression models that are appropriate for the variables being imputed, and uses random draws from predictive distributions based on the models for imputation. In this method, an imputation model is specified separately for each variable, including other variables from the dataset as predictors.

IVEware allows users to specify bounds for possible imputation values; therefore, bounds were set according to the minimum and maximum values for each stress measure. In addition, variable "type" was specified (i.e., continuous, count, binary). For the purposes of imputing the stress measures, we modeled stress variables with a normal distribution for continuous variables and a Poisson distribution for count variables, and we used the "mixed continuous variable" option for measures that included a high proportion of respondents with scores of the lowest possible value for that measure, but that otherwise had an approximately normal distribution (this was common for our stress measures); in this situation, the lowest value (0) was treated as a discrete category, while values greater than 0 were considered continuous.For variables that we modeled as continuous, or continuous mixed variables, we examined the distribution for each variable and experimented with transformations that could improve the normality of the distribution. When a transformation could be utilized to improve the normality of the distribution of a variable, this variable was transformed for the imputation procedure, and then detransformed in the final dataset.

The IVEware method uses all available information in the dataset to impute values; therefore, we developed a dataset that contained the variables for which imputations were necessary, as well as additional variables that had both high response rates and that we believed would be predictive of the variables we wished to impute (e.g., demographic variables, health outcome and behavior variables). Given that the relationships between the variables for each sample may be different, we performed the sequential regression imputation method on the Midus 2 and Milwaukee samples separately, under the assumption that this method would improve the precision of estimates for each sample.

Variable Naming Conventions

In the dataset 'midus_milwaukee_stress_summary.sas7dbat', the following conventions are used:

- **I_** in front of a variable name (e.g., I_SKILLDISC) indicates that it is the imputed form of the raw variable (SKILLDISC)
- **Z** in front of a variable (e.g., ZSKILLDISC) indicates that it is the standardized Z-score form
- **I_Z** in front of a variable indicates that an imputed variable has been standardized to a Z-score (e.g., I_ZSKILLDISC is the standardization of the imputed variable SKILLDISC)

Table 1. STRESS SUMMARY SCORES		
	Standardized Summary Score with Imputed Values	**Required Control Variables**
Psychological Work Stress	I_ZWORKMENTAL	(1) Current work status (CURRWORK)
Physical Work Stress	I_ZWORKPHYS	(1) Current work status (CURRWORK)
Work-family spillover	I_ZSPILL	(1) Current work status (CURRWORK)
Perceived Inequality	I_ZPERCINEQ	(1) Current work status (CURRWORK) (2) if R has 1+ child (HASCHLD)
Relationship Stress	I_ZRELSTRESS	(1) Current marital/partner status (MARPARTNER)
Neighborhood Disadvantage	I_ZNBHDQUAL	
Discrimination	I_ZDISC	(1) Current work status (CURRWORK)
Financial Stress	I_ZFINSTRESS	
Past Year Problems in Family	I_ZRECPROB	(1) Current marital/partner status (MARPARTNER) (2) R has 1+ child (HASCHLD)
Stressful Life Experiences	I_ZADULTSTRS	
Early Stress Experiences	I_ZEARLYSTRS	
Overall summary Score	I_ZSUMSTRESS	(1) Current work status (CURRWORK) (2) if R has 1+ child (HASCHLD) (3) current marital/partner status (MARPARTNER)

Table 2. INDIVIDUAL MEASURES IN EACH STRESS SUMMARY SCORE			
	Raw Stress Measure Variable	**Imputed Stress Measure Variable**	**Standardized Imputed Stress Variable**
Psychological Work Stress			
Skill Discretion	SKILLDISC	I_SKILLDISC	I_ZSKILLDISC
Decision Authority	DECAUTH	I_DECAUTH	I_ZDECAUTH
Demands	DEMANDS	I_DEMANDS	I_ZDEMANDS
Coworker Non-Support	CWNONSUPP	I_CWNONSUPP	I_ZCWNONSUPP
Supervisor Non-Support	SUPNONSUPP	I_SUPNONSUPP	I_ZSUPNONSUPP
Physical Work Stress			
Physical Strain	WORKSTRAIN	I_WORKSTRAIN	I_ZWORKSTRAIN
Risk of Injury on the Job	RISKINJ	I_RISKINJ	I_ZRISKINJ
Work-family spillover			
Negative Work-Family Spillover	NEGWF	I_NEGWF	I_ZNEGWF
Negative Family-Work Spillover	NEGFW	I_NEWFW	I_ZNEWFW
Perceived Inequality			
Perceived Inequality in Family	PERCFAM	I_PERCFAM	I_ZPERCFAM
Perceived Inequality in Home	PERCHOME	I_PERCHOME	I_ZPERCHOME
Perceived Inequality in Work	PERCWORK	I_PERCWORK	I_ZPERCWORK
Relationship Stress			
Family Strain	FAMSTRN	I_FAMSTRN	I_ZFAMSTRN
Friend Strain	FRSTRN	I_FRSTRN	I_ZFRSTRN
Marital Risk Scale	MARRISK	I_MARRISK	I_ZMARRISK
Spouse/Partner Strain Scale	SPSSTRN	I_SPSSTRN	I_ZSPSSTRN
Neighborhood			
Neighborhood Stress	NBHDQUAL	I_NBHDQUAL	I_ZNBHDQUAL
Discrimination			
Lifetime Discrimination	LIFEDI	I_LIFEDI	I_ZLIFEDI
Daily Discrimination	DAYDI	I_DAYDI	I_ZDAYDI
Chronic Job Discrimination	JOBDI	I_JOBDI	I_ZJOBDI
Financial Stress			
Financial Stress	FINSTRESS	I_FINSTRESS	I_ZFINSTRESS
Past Year Problems in Family			
Spouse/Partner	REC_SPS	I_REC_SPS	I_ZREC_SPS
Parents	REC_PAR	I_REC_PAR	I_ZREC_PAR
Children	REC_CH	I_REC_CH	I_ZREC_CH
Stressful Life Experiences			
Past 5 year events	P5YEVENTS	I_P5YEVENTS	I_ZP5YEVENTS
6+ Years Ago	P6YEVENTS	I_P6YEVENTS	I_ZP6YEVENTS
Early Stress Experiences			
Child Stress Experiences	CHILDEVENTS	I_CHILDEVENTS	I_ZCHILDEVENTS
Childhood Relationship with Parents	RELPAR	I_RELPAR	I_ZRELPAR
Verbal/Physical Assault by Parent	PARABUSE	I_PARABUSE	I_ZPARABUSE

1. PSYCHOLOGICAL WORK STRESS (5 measures)

1. **Skill Discretion**: see page 72 of MIDUS 2 scale documentation and page 65 of Milwaukee scale documentation for complete information on this scale [M2: B1SJCSD, Milwaukee: BASJCSD]

(3 items, range 1-5, all of the time → never)
Chronbach's Alpha: Midus 2: 0.70; Milwaukee: 0.76

a.	How often do you learn new things at work?
b.	How often does your work demand a high level of skill or expertise?
c.	How often does your job provide you with a variety of things that interest you?

NOTE:
- If B1SJCSD/BASJCSD=98 then set to missing '.'
- If B1SJCSD /BASJCSD=99 then set to 3, lowest valid response on scale
- If missing and individual is *not* currently working, set to 3.

2. **Decision Authority**: see page 74 of MIDUS 2 scale documentation and page 65 of Milwaukee scale documentation for complete information on this scale [M2: B1SJCDA, Milwaukee: BACJCDA]

(6 items, range 1-5, all of the time → never)
Chronbach's Alpha: Midus 2: 0.87; Milwaukee: 0.89

a.	On your job, how often do you have to initiate things – such as coming up with your own ideas, or figuring out on your own what needs to be done?
b.	How often do you have a choice in deciding how you do your tasks at work?
c.	How often do you have a choice in deciding what tasks you do at work?
d.	How often do you have a say in decisions about your work?
e.	How often do you have a say in planning your work environment – that is, how your workplace is arranged or how things are organized?
f.	How often do you control the amount of time you spend on task?

NOTE:
- If B1SJCDA /BASJCDA=98 then set to missing '.'
- If B1SJCDA /BASJCDA=99 then set to 6, lowest valid response on scale
- If missing and individual is *not* currently working, set to 6.

3. **Demands Scale:** see page 72 of MIDUS 2 scale documentation and page 65 of Milwaukee scale documentation for complete information on this scale [M2: B1SJCDS, Milwaukee BASJCDS]

(5 items, range 1-5, all of the time → never)
Chronbach's Alpha: Midus 2: 0.73; Milwaukee: 0.61

a.	How often do have to work very intensively – that is, you are very busy trying to get things done?
b.	How often do different people or groups at work demand things from you that you think are hard to combine?
c.	How often do you have too many demands made on you?
d.	How often do you have a lot of interruptions?

NOTE:
- If B1SJCDS /BASJCDS=98 then set to missing '.'

- If B1SJCDS /BASJCDS=99 then set to 5, lowest valid response on scale
- If missing and individual is *not* currently working, set to 5.

4. **Coworker Non-Support:** see page 73 of MIDUS 2 scale documentation and page 66 of Milwaukee scale documentation for complete information on this scale [M2: B1SJCCS, Milwaukee: BASJCCS]

(2 items, range 1-5, all of the time → never)
Chronbach's Alpha: Midus 2: 0.67; Milwaukee: 0.68

a.	How often do you get help and support from your coworkers?
b.	How often are your coworkers willing to listen to your work-related problems?

NOTE:

- Reverse coded B1SJCCS /BASJCCS
- If B1SJCCS /BASJCCS=98 then set to missing '.'
- If B1SJCCS=99 then set to 2, the lowest value on the scale
- If missing and individual is *not* currently working, set to 2.

5. **Supervisor Non-Support**: see page 73 of MIDUS 2 scale documentation and page 66 of Milwaukee scale documentation for complete information on this scale [M2: B1SJCSS, Milwaukee: BASJCSS]

(3 items, range 1-5, all of the time → never)

a.	How often do you get the information you need from your supervisor or superiors?
b.	How often do you get help and support from your immediate supervisor?
c.	How often is your immediate supervisor willing to listen to your work-related problems?

NOTE:

- Reverse coded B1SJCSS /BASJCSS
- If B1SJCSS /BASJCSS=98 then set to missing '.'
- If B1SJCSS=99 then set to 3, the lowest value on the scale
- If missing and individual is *not* currently working, set to 3.

2. PHYSICAL WORK STRESS (2 measures)

1. **Occupational Physical Strain**: This is a scale we created ourselves. See page 6 of MIDUS 2 SAQ2 and page 31 of Milwaukee SAQ to view questions.

(9 items, range 1-5, never→ all of the time)
Chronbach's Alpha: Midus 2: 0.92; Milwaukee: 0.94

a.	How often does your job require a lot of physical effort? (B1SF23A/ BASE1A)
b.	How often does your job require you to lift loads weighing 50 pounds or greater? (B1SF23B/ BASE1B)
c.	How often does your job require you to lift loads weighing less than 50 pounds, but greater than 10 pounds? (B1SF23C/ BASE1C)
d.	How often does you job require you to lift loads weighing up to 10 pounds? (B1SF23D/ BASE1D)
e.	How often does you job require you to crouch, stoop or kneel? (B1SF23E/ BASE1E)
f.	How often does you job require you to stand for long periods of time? (B1SF23F/ BASE1F)
g.	How often does your job require you to use stairs or inclines? (B1SF23G/ BASE1G)
h.	How often does you job require you to walk? (B1SF23H/ BASE1F)
i.	How often does you job require you to reach? (B1SF23J/ BASE1J)

NOTE:

- Items were reverse coded so that 1= "never" and 5= "all the time".
- If an individual item had a response of 8, it was set to missing.
- If individual response had a value of '9' on an item (N/A), they were given the lowest item value (1).
- The scale was calculated by summing the items, then calculating the mean score , and multiplying by 9 (the # of items in the scale) in order to account for missing values on some items.
- Questions were administered to people who had worked in the past 10 years; therefore, if a person had missing data and had *not* worked in the past 10 yrs. they were given the lowest value for each item (1).

2. **Risk of Injury on the Job:** see page 7 of Midus 2 SAQ2 and page 31 of Milwaukee SAQ for question.

(1 item, range 1 to 4, a lot → not at all) [M2: B1SF24, Milwaukee: BASE2]

a. To what extent, over the past ten years, have you been exposed to the risk of accidents or injuries on your job?

NOTE:

- Item was reverse coded so that higher scorer represented greater job insecurity.
- If B1SF24/ BASE2=8, then item set to missing
- If B1SF24/ BASE2=9, then item set to the lowest value on the scale, 1.
- If missing and individual is *not* currently working, set to 1.

3. WORK-FAMILY SPILLOVER (2 measures)

1. **Negative work-to-family spillover**: see page 69 of MIDUS 2 scale documentation and page 62 of Milwaukee scale documentation for complete information on this scale [M2: B1SNEGWF, Milwaukee: BASNEGWF)

(4 items, range 1-5, all of the time → never)

Chronbach's Alpha: Midus 2: 0.82; Milwaukee: 0.82

a.	Your job reduces the effort you can give to activities at home.
b.	Stress at work makes you irritable at home.
c.	Your job makes you feel too tired to do the things that need attention at home.
d.	Job worries or problems distract you when you are at home.

NOTE:

- If B1SNEGWF/ BASNEGWF =98 then set to missing '.'
- If B1SNEGWF/ BASNEGWF =99 then set to 4, lowest valid response on scale
- If missing and individual is *not* currently working, set to 4.

2. **Negative family-to-work spillover**: see page 69 of MIDUS 2 scale documentation and page 62 of Milwaukee scale documentation for complete information on this scale [M2: B1SNEGFW, Milwaukee: BASNEGFW]

(4 items, range 1-5, all of the time → never)

Chronbach's Alpha: Midus 2: 0.80; Milwaukee: 0.80

a.	Responsibilities at home reduce the effort you can devote to your job.
b.	Personal or family worries and problems distract you when you are at work.
c.	Activities and chores at home prevent you from getting the amount of sleep you need to do your job well.
d.	Stress at home makes you irritable at work.

NOTE:

- If B1SNEGFW/ BASNEGFW =98 then set to missing '.'

- If B1SNEGFW/ BASNEGFW =99 then set to 4, lowest valid response on scale
- If missing and individual is *not* currently working, set to 4.

4. PERCEIVED INEQUALITY (3 measures)

1. **Perceived inequality in family**: see page 96 of MIDUS 2 scale documentation and page 88 in Milwaukee scale documentation for complete information on this scale [M2: B1SPIFAM, Milwaukee: BACPIFAM]

(6 items, range 1-4, not at all true → extremely true)
Chronbach's Alpha: Midus 2: 0.71; Milwaukee: 0.56

a. I feel good about the opportunities I have been able to provide for my children.
b. It seems to me that family life with my children has been more negative than most people's.
c. Problems with my children have caused me shame and embarrassment at times.
d. As a family, we have not had the resources to do many fun things together with the children.
e. I believe that I have been able to do as much for my children as most other people.
f. I feel a lot of pride about what I have been able to do for my children.

NOTE:
- If B1SPIFAM/ BACPIFAM =8, then set to missing
- If B1SPIFAM/ BACPIFAM =9 then set to 1
- For individuals with a missing value on this scale who do *not* have one or more children, set to lowest value on the scale (1).

2. **Perceived inequality in home**: see page 88 of MIDUS 2 scale documentation and page 81 of Milwaukee scale documentation for complete information on this scale [M2: B1SPIHOM, Milwaukee: BACPIHOM]

(6 items, range 1-4, a lot → not at all)
Chronbach's Alpha: Midus 2: 0.78; Milwaukee: 0.65

a. I live in as nice a home as most people.
b. I'm proud of my home.
c. Most people live in a better neighborhood than I do.
d. I don't like to invite people to my home because I do not live in a very nice place.
e. I feel very good about my home and neighborhood.
f. It feels helpless to try to improve my home and neighborhood situation.

NOTE:
- If B1SPIHOM/ BACPIHOM =8 then set to missing
- If B1SPIHOM/ BACPIHOM =9 then set to 1, lowest valid response on the scale.

3. **Perceived inequality in work**: see page 78 of MIDUS 2 scale documentation and page 71 of Milwaukee documentation for complete information on this scale [M2: B1SPIWOR, Milwaukee: BASPIWOR)

(6 items, range 1-4, a lot → not at all)
Chronbach's Alpha: Midus 2: 0.75; Milwaukee: 0.64

a. I feel cheated about the chances I have had to work at good jobs.

b.	When I think about the work I do on my job, I feel a good deal of pride.
c.	I feel that others respect the work I do on my job.
d.	Most people have more rewarding jobs than I do.
e.	When it comes to my work life, I've had opportunities that are as good as most people's.
f.	It makes me feel discouraged that other people have much better jobs than I do.

NOTE:

- If B1SPIWOR/ BASPIWOR =8 then set to missing
- If B1SPIWOR/ BASPIWOR =9 then set to 1, lowest valid response on the scale
- If individual has a missing value on this scale and is *not* currently working, set to lowest value.

5. RELATIONSHIP STRESS (4 measures)

1. **Family Strain:** see page 90 of MIDUS 2 scale documentation and page 82 of Milwaukee scale documentation for complete information on this scale [M2: B1SKINNE, Milwaukee: BACKINEE]

(4 items, range 1-4, often → never)
Chronbach's Alpha: Midus 2: 0.79; Milwaukee: 0.80

a.	Not including your spouse or partner, how often do members of your family make too many demands on you?
b.	How often do they criticize you?
c.	How often do they let you down when you are counting on them?
d.	How often do they get on your nerves?

NOTE:

- If B1SKINNE / BACKINEE =8 then set to missing '.'

2. **Friend Strain:** see page 94 of MIDUS 2 scale documentation and page 86 of Milwaukee scale documentation for complete information on this scale [M2: B1SFDSNE, Milwaukee: BACFDSNE]

(4 items, range 1-4, often → never)
Chronbach's Alpha: Midus 2: 0.79; Milwaukee: 0.80

a.	How often do your friends make too many demands on you?
b.	How often do they criticize you?
c.	How often do they let you down when you are counting on them?
d.	How often do they get on your nerves?

NOTE:

- If B1SFDSNE/ BACFDSNE =8 then set to missing '.'

3. **Marital Risk Scale:** see page 98 of MIDUS 2 scale documentation and page 90 of Milwaukee scale documentation for complete information on this scale [M2: B1SMARRS, Milwaukee: BACMARRS]

(5 items, range varies, specified below)
Chronbach's Alpha: Midus 2: 0.77; Milwaukee: 0.64

a. During the past year, how often have you thought your relationship might be in trouble?(ranges 1-5, never → all the time)
b. Realistically what do you think the chances are that you and your partner will eventually separate? (ranges 1-4, not likely at all → very likely)
c. How much do you and your spouse or partner disagree on the following issues?
   i. Money matters, such as how much to spend, save or invest?
   ii. Household tasks, such as what needs doing and who does it?
   iii. Leisure time activities, such as what to do and with whom? (ranges 1-4, not at all → a lot)

NOTE:

- If B1SMARRS/ BACMARRS =8 then set to missing
- If B1SMARRS/ BACMARRS =9 then set item to 1,the lowest valid response on the scale
- If missing, and individual does not currently have a spouse or partner, set to lowest value on the scale

4. **Spouse/partner strain scale**: see page 101 of MIDUS 2 scale documentation and page 93 of Milwaukee scale documentation for complete information on this scale [M2: B1SSPCRI, Milwaukee: BACSPCRI]

(6 items, range 1-4, a lot → not at all)
Chronbach's Alpha: Midus 2: 0.87; Milwaukee: 0.83

a. How much does your spouse or partner really care about you?
b. How much does he or she understand the way you feel about things?
c. How much does he or she appreciate you?
d. How much do you rely on him or her for help if you have a serious problem?
e. How much can you open up to him or her if you need to talk about your worries?
f. How much can you relax and be yourself around him or her?

NOTE:

- If B1SSPCRI/ BACSPCRI =8 then set to missing
- If B1SSPCRI/ BACSPCRI =9 then set item to 1, lowest valid response on the scale
- If missing, and individual does not currently have a spouse or partner, set to lowest value on the scale

6. NEIGHBORHOOD STRESS (1 measure)

1. **Personal Beliefs on Neighborhood:** see page 87 of MIDUS 2 scale documentation and page 80 of Milwaukee scale documentation for complete information on this scale [M2: B1SHOMET, Milwaukee: BACHOMET)

(4 items, range 1-4, a lot → not at all)
Chronbach's Alpha: Midus 2: 0.64; Milwaukee: 0.59

a. I feel safe being out alone in my neighborhood during the daytime.
b. I feel safe being out alone in my neighborhood at night.
c. I could call on a neighbor for help if I needed it.
d. People in my neighborhood trust each other.

NOTE:

- The created scale B1SHOMET/BACHOMET had reverse coded the items 6a, 6b, 6e, 6g, In order to make a scale where the highest score presented the greatest amount of stress, I recreated the scale by summing together the 4 individual items (*not* reverse coded), and then taking the mean response of the 4 items.

7. DISCRIMINATION (3 measures)

1. **Lifetime Discrimination**: see page 111 of MIDUS 2 scale documentation and page 103 of Milwaukee scale documentation for information [M2: B1SLFEDI, Milwaukee: BACLFEDI)
(11 items, count)

"How many times in your life have you been discriminated against in each of the following ways because of such things as your race, ethnicity, gender, age, religion, physical appearance, sexual orientation, or other characteristics?"

a. You were discouraged by a teacher or advisor from seeking higher education.
b. You were denied a scholarship.
c. You were not hired for a job.
d. You were not given a promotion.
e. You were fired.
f. You were prevented from renting or buying a home in the neighborhood you wanted.
g. You were prevented from remaining in a neighborhood because neighbors made life so uncomfortable.
h. You were hassled by the police.
i. You were denied a bank loan.
j. You were denied or provided inferior service by a plumber, car mechanic, or other service provided.

NOTE:

- In Midus 2, if B1SLFEDI=99998 then set to missing; no missing in Milwaukee

2. **Daily Discrimination:** see page 111 of MIDUS 2 scale documentation and page 103 of Milwaukee scale documentation for complete information on this scale (B1SDAYDI)
(9 items, range 1-4, often → never)
Chronbach's Alpha: Midus 2: 0.92; Milwaukee: 0.88

a. You are treated with less courtesy than other people.
b. You are treated with less respect than other people.
c. You receive poorer service than other people at restaurants or stores.
d. People act as it if they think you are not smart.
e. People act as if they are afraid of you.
f. People act as if they think you are dishonest.
g. People act as if they think you are not as good as they are.
h. You are called names or insulted.
i. You are threatened or harassed.

Notes for MIDUS 2: If B1SDAYDI=98 then set to missing

Notes for Milwaukee: We revised the coding of this measure a great deal, in order to make it as similar as possible to the measure collected in Midus 2 . Unlike in Midus 2, in Milwaukee individuals were first asked if they ever experienced an event, and, if they responded YES, then they were asked to report the frequency of the event. Individuals were left out of the scale if they responded NO.

Several steps were taken in creating measure for Milwaukee:

1. If an individual had a "NO" responses to BACDISC12 through BACDISC20, then individuals were given a value of '4' ("NEVER") on the frequency of daily discrimination questions (BACPS2A through BACPS2I).
2. Items BACPS2A through BACPS2I were then reverse coded so that more frequent discrimination experiences would have a higher score.
3. Scale values were only computed for individuals with 5 or more valid item responses.
4. Mean values for items with a missing value were computed by summing valid responses, taking the mean, and multiplying this value by 9 (the # of items)

***This was our best approximation of the Daily Discrimination scale that was collected in Midus 2, but it is a problem to compare Midus and Milwaukee participants on this measure, since the samples differ in the way that the survey questions were asked.

3. **Chronic Job Discrimination**: See page 76 of MIDUS 2 scale documentation and 69 of Milwaukee documentation for complete information on this scale [M2: B1SJOBDI, Milwaukee: BASJOBDI].

(6 items, range 1-5, once a week or more → never)
Chronbach's Alpha: Midus 2: 0.76; Milwaukee: 0.88

a. How often do you think you are unfairly given the jobs that no one else wanted to do?
b. How often are you watched more closely than other workers?
c. How often does your supervisor or boss use ethnic, racial or sexual slurs or jokes?
d. How often do your coworkers use ethnic, racial, or sexual slurs or jokes?
e. How often do you feel that you are ignored or not taken seriously by your boss?
f. How often has a coworker with less experience and qualifications than you gotten promoted before you?

NOTE:
- If B1SJOBDI/ BASJOBDI =98 then set to missing '.'
- If B1SJOBDI/ BASJOBDI =99 then set B1SJOBDI/ BASJOBDI to 6, the lowest response on the scale
- If individual is missing a valid response on the measure, and is *not* currently working, set to lowest value on the scale.

8. CURRENT FINANCIAL STRESS (1 measure)

1. **Financial Stress** (2 items): See page 13 of Midus 2 SAQ2 and page 102 of Milwaukee CAPI instrument for questions.

Chronbach's Alpha: Midus 2: 0.79; Milwaukee: 0.66

a. In general, would you say you (and your family living with you) have more money than you need, just enough money for your needs, or not enough money to meet your needs?

(ranges 1-3, more $ than you need → not enough $) [M2: B1SG6, Milwaukee: BACGS7]

b. How difficult is it for you (and your family) to pay your monthly bills?

(ranges 1-4, very difficult → not at all difficult) [M2: B1SG7, Milwaukee: BACGS7]

NOTE:
- Reverse coded B1SG7/BACGS7, and then summed together valid responses on these two items to create the scale.

9. RECENT PROBLEMS IN IMMEDIATE FAMILY (3 measures)

1. **Past Year Problems for Spouse/Partner:** see page 31 in Midus 2 SAQ2 and page 130 in Milwaukee CAPI instrument for questions.

(10 items each, coded as 0/1)
"In the past 12 months, did your SPOUSE have:" [M2: B1SJ7SA-B1SJ7SJ, Milwaukee: BACJS7SA-BACJS7SJ]

a.	Chronic disease or disability?
b.	Frequent minor illness?
c.	Emotional problems (such as sadness, anxiety)?
d.	Alcohol or substance problems?
e.	Financial problems, such as low income or heavy debts?
f.	Problems at school or at work (such as failing grades, poor job performance)?
g.	Difficulty finding or keeping a job?
h.	Marital or partner relationship problems?
i.	Legal problems (such as involved in law suits, police changes, traffic violations)?
j.	Difficulty getting along with people?

NOTE:
- For each item, responses of 2 or 3 were set to 0.
- Response of 8 set to missing.
- Score was calculated by summing together the 10 items.
- If an individual had a missing value on this scale, and did *not* have a spouse or partner at the time, they were set to the lowest value for this scale (0).

2. **Past Year Problems for Parents**: see page 31 in Midus 2 SAQ2 and page 131 in Milwaukee CAPI instrument for questions [M2: B1SJ7PA-B1SJ7PJ, Milwaukee: BACJS7PA-BACJS7PJ] (10 items each, coded as 0/1)

"In the past 12 months, did your PARENTS have:" [same list as above]

NOTE:
- For each item, responses of 2 or 3 were set to 0.
- Response of 8 set to missing.
- Score was creating by summing together the 10 items.

3. **Past Year Problems for Children** see page 31 in Midus 2 SAQ2 and page 131 in Milwaukee CAPI instrument for questions [M2: B1SJ7CA-B1SJ7CJ, Milwaukee: BACJS7CA-BACJS7CJ] (10 items each, coded as 0/1)

"In the past 12 months, did your CHILDREN have:" [same list as above]

NOTE:
- For each item, responses of 2 or 3 were set to 0.
- Response of 8 set to missing.
- Score was creating by summing together the 10 items.
- If an individual had a missing value on this scale, and did *not* currently have any children, they were set to the lowest value for this scale (0).

10. STRESSFUL LIFE EXPERIENCES (2 measures)

1. Past 5 Year events: see list on pages 49-51 of Midus 2 SAQ1, and pages 144-164 in Milwaukee CAPI instrument. [Midus 2: B1SE11H through B1SE11AA, Milwaukee: BACES11H through BACES11AA]

Listing of 20 events; a count variable was created for "YES" responses. If the individual responded "YES", he or she was asked to report the age at which the event occurred, which made it possible to identify events occurring within the past 5 years)

a. flunked out of school;
b. fired from a job;
c. did not have a job for a long time when you wanted to be working;
d. a parent died;
e. parents divorced;
f. spouse/partner engaged in (marital) infidelity;
g. significant difficulty with in-laws;
h. brother or sister died;
i. child died;
j. child experienced life threatening accident or injury;
k. lost your home to a fire, flood, natural disaster, etc.;
l. physically assaulted or attacked;
m. sexually assaulted;
n. serious legal difficulties/prison;
o. detention in jail or comparable institution;
p. declared bankruptcy;
q. suffered a financial or property loss unrelated to work;
r. went on welfare;
s. entered the armed forces;
t. experienced combat;

2. Lifetime Stress Events (6+ years ago, or no age identified): see same pages as noted above. Listing of 23 events; (score includes variables identified as occurring 6 or more years ago, OR with no identified age).

Same list as above, PLUS 3 additional variables:

a. homeless in past 15 years [M1 (A1PE2) or M2 (B1PE2); Milwaukee: BACE2]
b. no telephone in home or apartment in past 15 years [M1 (A1PE3) or M2 (B1PE3), Milwaukee BACE3]
c. marriage ended in divorce or widowhood [created from B1PB19 and B1PB22 for MIDUS 2; created from BACB19 and BACB22 in Milwaukee]

NOTE: We determined whether or not the event occurred in the past 5 years based on the ages provided to accompany affirmative response to a stressful event.

- In Midus 2, the ages were provided in variables B1SE11H1 through B1SE11AW.
- In Milwaukee, individuals could report up to 6 different ages at which the event occurred (for example, for BACES11H, variables BACES11H11 through BACES11H16 contain the ages at which an individual experienced BACES11H). Since ages were reported in chronologic order, I used the age reported in the last valid response from the list of provided ages at which the event occurred.
- If an individual had an affirmative response to a stressful event, but did not report the age of occurrence, then the age was set to the value of 0, so that the event would be placed into the lifetime stress/6+ years ago category. If an individual reported an age that was within 5 years of their current age (M2: B1PAGE_M, Milwaukee: BACRAGE), then it was included in the score for past 5 year events.
- If an individual did not have any valid responses to items B1SE11H-B1SE11AA (M2) or BACES11H-BACES11AA (Milwaukee), then they were not given a score for either Past 5 Year events, or Lifetime Events (Events 6+ Years Ago).

11. EARLY STRESS EXPERIENCES (3 measures)

1. **Count of Child-Adolescent-Specific Stress Experiences:** The first 7 items on the list of stressful life experiences is on page 48 of Midus 2 SAQ1 and pages 138-144 in Milwaukee CAPI. This list also included 2 additional stressful experiences (taken from Midus 1 for MIDUS 2 sample, and part of Milwaukee interview). First 7 items: M2: B1SE11A through B1SE11G, Milwaukee BACES11A through BACES11G.

(9 items total, created a count variable for "yes" responses)

a. repeated a year of school
b. sent away from home because you did something wrong
c. father or mother did not have a job when they wanted to be working
d. one or both parents drank so often it caused problems
e. one or both parents used drugs so often it regularly caused problems
f. dropped out of school
g. expelled or suspended from school
h. ever received welfare or ADC for a period of 6 months or more during childhood or adolescence [MIDUS 1: A1PC14=1, Milwaukee: BACCA14=1]
i. moved to a totally new neighborhood or town 2 or more times during childhood [MIDUS 1: A1SE8>=2, Milwaukee BACEA8>=2]

NOTE:

- If individual is missing B1SE11A through B1SE11G, then set as missing on this measure.

2. **Relationship with Parents**: see page 29-30 of Midus 1 SAQ, and pages 122-123 of Milwaukee CAPI for questions.

(2 item, range from 1 to 5, 1=excellent, 5=poor)
Chronbach's Alpha: Midus 2: 0.56; Milwaukee: 0.24

a. How would you rate your relationship with your mother during the years you were growing up? [MIDUS1: A1SE13, Milwaukee: BACEA13]
b. How would you rate your relationship with your father during the years you were growing up? [MIDUS1: A1SE15, Milwaukee: BACEA15]

NOTE:

- If A1SE13=8 then set to missing; if A1SE13=9 then set to lowest value (1)
- If A1SE15=8 then set to missing; if A1SE15=9 then set to lowest value (1)
- If BACEA13= 7 or 8 then set to missing; if BACEA13=9 then set to lowest value (1)
- If BACEA15= 7 or 8 then set to missing; if BACEA15=9 then set to lowest value (1)
- Sum together the responses from the two questions to get score for this measure.

3. **Verbal or Physical Assault by Parents**: see page 32 from MIDUS 1 SAQ1, and page 28 from Milwaukee SAQ for questions.

(6 items, range 0-3, never → often)
Chronbach's Alpha: Midus 2: 0.82; Milwaukee: 0.84

a. During your childhood, how often did your mother, or the woman who raised you, do any of the things on List A to you? (insulted you or swore at you; sulked or refused to talk to you; stomped out of the room; did or said something to spite you; threatened to hit you; smashed or kicked something in anger) [Midus 1: A1SE17A, Milwaukee: BASD1A]
b. During your childhood, how often did your mother, or the woman who raised you, do any of the things on List B to you? (pushed, grabbed or shoved you; slapped you; threw something at you) [Midus 1: A1SE17F, Milwaukee: BASD2A]
c. During your childhood, how often did your mother, or the woman who raised you, do any of the things on List C to you? (kicked, bit, or hit you with a fist; hit or tried to hit you with something; beat you up; choked you; burned or scalded you) [Midus 1: A1SE17K, Milwaukee: BASD3A]
d. During your childhood, how often did your father, or the man who raised you, do any of the things on List A to you? (insulted you or swore at you; sulked or refused to talk to you; stomped out of the room; did or said something to spite you; threatened to hit you; smashed or kicked something in anger) [Midus 1: A1SE17B, Milwaukee: BASD1B]
e. During your childhood, how often did your father, or the man who raised you, do any of the things on List B to you? (pushed, grabbed or shoved you; slapped you; threw something at you) [Midus 1: A1SE17G, Milwaukee: BASD2B]
f. During your childhood, how often did your father, or the man who raised you, do any of the things on List C to you? (kicked, bit, or hit you with a fist; hit or tried to hit you with something; beat you up; choked you; burned or scalded you) [Midus 1: A1SE17L, Milwaukee: BASD3B]

NOTE:

- We reverse coded questions from the Conflict Tactics Inventory so that a higher value represents more frequent abuse.
- Changed scale from 1-4 to 0-3 to match other literature that has used this scale.
- Scale was calculated if individual had any valid responses on either measure.
- If an item had a value of 8, set to missing. If an item had a response of 9 (N/A) set to lowest value on item (0).

12. Standardized Summary Measure

The standardized overall summary measure was created by summing together all of the standardized scores from the stress summary measures, and then the summary score was standardized to have a mean of 0 and a standard deviation of 1.

Control Variables Used to Substitute Lowest Value for Individuals with Missing Information who were Ineligible to Experience a Particular Stressor

1. Current Employment Status

Variable Name: CURRWORK
Imputed Version: I_CURRWORK

CURRWORK=0 → individual is not currently working
CURRWORK=1 → individual is currently employed (defined as a response of "working now", "self-employed", "doing any work for pay at the present time" and "currently doing any work for pay" qualified an individual to be "currently working").

Applied to: (1) Psychological work stress
(2) Physical work stress
(3) Work-Family Spillover
(4) Discrimination
(5) Overall Summary Stress Score

Variables used to create CURRWORK:
Midus 2: B1PB3a, B1PB3b, B1PB6, B1SF13
Milwaukee: BACB3a, BACB3b, BACB6

2. Currently Married or Living with a Partner in a Marriage-Like Relationship

Variable Name: MARPARTNER
Imputed Version: I_MARPARTNER

MARPARTNER=0 → not married or living with partner in marriage-like relationship
MARPARTNER=1 → currently married or living with a partner in a marriage-like relationship

Applied to: (1) Relationship Stress
(2) Past Year Problems in Family
(3) Overall Summary Stress Score

Variables used to create MARPARTNER:
Midus 2: B1PB19, B1PB30
Milwaukee: BACB19, BACB30

3. Respondent Has 1 or More Child

Variable Name: HASCHLD
Imputed Version: I_HASCHLD

HASCHLD=0 → Respondent does not have any children
HASCHLD=1 → Respondent has one or more children

Applied to: (1) Perceived Inequality
(2) Past Year Problems in Family
(3) Overall Summary Stress Score

Variables used to create HASCHLD:
Midus 2: B1PC2
Milwaukee: BACCHLD

Table 3. Description of Missing Data Prior to Imputation

Variable	Variable Name	MIDUS 2				Milwaukee			
		Admin	N	Missing	% Missing	Admin	N	Missing	% Missing
Skill Discretion	skilldisc	SAQ	4149	814	0.164	SAQ	450	142	0.240
Decision Authority	decauth	SAQ	4149	814	0.164	SAQ	450	142	0.240
Job Demands	demands	SAQ	4148	815	0.164	SAQ	452	140	0.236
Coworker Nonsupport	cwnonsupp	SAQ	4146	817	0.165	SAQ	452	140	0.236
Supervisor Nonsupport	supnonsupp	SAQ	4144	819	0.165	SAQ	452	140	0.236
Physical work strain	workstrain	SAQ	3980	983	0.198	SAQ	410	182	0.307
Risk of injury on job	riskinj	SAQ	4232	731	0.147	SAQ	464	128	0.216
Negative W-F Spillover	negwf	SAQ	4148	815	0.164	SAQ	450	142	0.240
Negative F-W Spillover	negfw	SAQ	4147	816	0.164	SAQ	450	142	0.240
Perceived Ineq. In family	percfam	SAQ	4147	816	0.164	CAPI	589	3	0.005
Perceived Ineq. In Home	perchome	SAQ	4007	956	0.193	CAPI	591	1	0.002
Perceived Ineq in Work	percwork	SAQ	4145	818	0.165	SAQ	464	128	0.216
Friend Strain	frstrn	SAQ	3990	973	0.196	ACASI	579	13	0.022
Family Strain	famstrn	SAQ	4003	960	0.193	ACASI	586	6	0.010
Marital Risk Scale	marrisk	SAQ	4254	709	0.143	ACASI	592	0	0.000
Spouse Strain	spsstrn	SAQ	4256	707	0.142	ACASI	592	0	0.000
Neighborhood Stress	nbhdqual	SAQ	4009	954	0.192	CAPI	591	1	0.002
Lifetime Discrimination	lifedi	SAQ	3871	1092	0.220	ACASI	592	0	0.000
Daily Discrimination	daydi	SAQ	3969	994	0.200	ACASI	584	8	0.014
hronic Job Discrimination	jobdi	SAQ	4137	826	0.166	SAQ	464	128	0.216
Financial Stress	finstress	SAQ	3984	979	0.197	CAPI	590	2	0.003
Past Yr Problems: Spouse	rec_sps	SAQ	4198	765	0.154	CAPI	592	0	0.000
Past Yr Problems: Parents	rec_par	SAQ	3878	1085	0.219	CAPI	592	0	0.000
Past Yr Problems: Children	rec_ch	SAQ	4053	910	0.183	CAPI	592	0	0.000
Stressful Events: past 5 yrs	p5yevents	SAQ	3823	1140	0.230	CAPI	592	0	0.000
Stressful Events: 6+ yrs ago	p6yevents	SAQ	3823	1140	0.230	CAPI	592	0	0.000
Stressful Events: Childhood	childevents	SAQ	2993	1970	0.397	CAPI	592	0	0.000
Relationship with Parents	relpar	SAQ	4668	295	0.059	CAPI	590	2	0.003
Abuse by Parents	parabuse	SAQ	4653	310	0.062	SAQ	395	197	0.333

CURRICULUM VITAE

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Education

2011	Ph.D., Human Development and Family Studies, The Pennsylvania State University – University Park
2008	M.S., Human Development and Family Studies, The Pennsylvania State University – University Park
2005	B.A., *cum laude*, Psychology and Social Behavior, Philosophy, University of California, Irvine

Selected Research and Teaching Experience

2009-2011	Research Assistant, *Workplace Practices and Daily Family Well-Being* (Co-PIs: Drs. David M. Almeida, Laura C. Klein, Susan M. McHale, Ann C. Crouter)
2009-2010	Research Assistant, *Hotel Work and Well-Being* (Co-PIs: Drs. Ann C. Crouter, Susan M. McHale, David M. Almeida, Laura C. Klein)
2005-2010	Research Assistant, *The National Study of Daily Experiences* (PI: Dr. David M. Almeida)
2011	Instructor, *Adolescent Development*
2010	Volunteer Teaching Assistant, *Adult Development and Aging*
2010	Co-Instructor, *Introduction to Human Development and Family Studies*
2008	Teaching Assistant, *Advanced Child Development*

Selected Presentations and Publications

King, H. A., Dmitrieva, N. O., & Almeida, D. M. (2011, November). Neuroticism in daily life: Physical health symptoms and health behaviors. In G. W. Edmonds (Chair), *Personality Traits and Processes: Associations with Lifestyles, Health and Mortality*. Symposium presented at the 64th Annual Scientific Meeting of the Gerontological Society of America, Boston, MA.

Dmitrieva, N. O., Charles, S. T., & Almeida, D. M. (2010, November). *Age and physiological vulnerability to increasing negative family-work spillover*. Paper presented at the 63rd Annual Scientific Meeting of the Gerontological Society of America, New Orleans, LA.

Piazza, J. R., Almeida, D. M., Dmitrieva, N. O., & Klein, L. C. (2010). Frontiers in the use of biomarkers of health in research on stress and aging. *Journals of Gerontology, Psychological Sciences, 65B*, 513-525.

Dmitrieva, N. O., Stawski, R. S., & Almeida, D. M. (2010, March). *Everything in moderation: Too much or too little sleep is associated with higher evening cortisol levels.* Citation poster presented at the 68th Annual Meeting of the American Psychosomatic Society, Portland, OR.