

Combined Effects of Cumulative Stress and Daily Stressors on Daily Health

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Objective: It has been proposed that cumulative stress, one's experience of chronic stressors across multiple domains, worsens health by altering the extent to which daily stressors impact daily affect and physical symptoms. Recent work confirms that high cumulative stress exacerbates the association between daily stressor exposure and increased daily negative affect, though it remains untested the extent to which cumulative stress and daily stressor exposure interact to predict daily symptoms. **Method:** We employed data from the second wave of the midlife in the U.S. Survey ($N = 2,022$; $M_{age} = 56.2$; 57.2% female) to examine whether levels of cumulative stress compound daily symptoms on days with (vs. without) stressful events. Experiences of life stressors across eight domains, occurrence of daily stressors, and occurrence, number, and severity of daily physical symptoms were analyzed using multilevel modeling. **Results:** Greater cumulative stress and experiencing (vs. not experiencing) a daily stressor independently increased the odds of occurrence, number, and severity of daily symptoms ($ps \leq .016$). Moreover, after adjusting for covariates (e.g., sociodemographic characteristics, chronic health conditions, percent of days with reported stressors, and health behaviors), the associations between daily stressor exposure and odds of occurrence, number, and severity of daily symptoms were potentiated as levels of cumulative stress increased ($ps \leq .009$). **Conclusions:** The negative implications of daily stressor exposure for daily health may be most pronounced in those who report higher levels of cumulative stress across multiple life domains and across time.

Keywords: psychological stress, chronic stress, physical health, symptoms

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Chronic stressors, life events which are psychologically taxing and have persisted over time, are consistently associated with poor health, such as chronic health conditions (e.g., cancer, cardiovascular conditions) and earlier mortality (e.g., Nandi et al., 2014; Robinette et al., 2016). Moreover, accumulated exposure to chronic stressors across a variety of life domains, and the perceived psychological burden of such exposures, is particularly detrimental to health and well-being (e.g., significantly heightened odds of obesity when exposed to stressors across multiple vs. a single life domain; Cuevas et al., 2019; Evans

et al., 2013; Slopen et al., 2018). Such findings highlight the importance of measuring cumulative chronic stress as experienced across multiple life domains (heretofore referred to as “cumulative stress”).

Although one's exposure to and appraisal of chronic stressors are speculated to worsen health by influencing daily experiences (Epel et al., 2018), the mechanisms underlying the association between cumulative stress and daily health are unclear. Recent research demonstrates that cumulative stress and daily stressor exposure interact to predict worsened daily negative affect (Lockwood et al., 2022).

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Extending this work, we use nationally representative longitudinal data to examine whether cumulative stress compounds the association between daily stressor exposure and daily physical health symptoms.

Cumulative Stress

Cumulative stress as a composite score accounts for one's exposure to and appraisal of chronic stressors (i.e., stressors which have persisted for at least 6 months; Epel et al., 2018) as experienced across a variety of domains (e.g., work, relationships) and across time (Slopen et al., 2018). Whereas chronic stress measures are typically specific to one life domain, cumulative stress has the additive value of measuring stressor exposure and associated psychological appraisals across multiple realms of life (Slopen et al., 2018). For example, whereas financial strain can be classified as a chronic stressor, cumulative stress would encompass one's experience of financial strain in addition to their experiences of chronic stressors across several other domains (e.g., perceived deprivation, discrimination, neighborhood stress). Stress accumulation across multiple domains of life and their additive detrimental impact on health and well-being has a long history in health psychology, with earlier conceptualizations of stress spillover and contagion across different roles, domains, and family members (e.g., Bolger et al., 1989; Wethington, 2000).

Different approaches have been used to operationalize cumulative stress in large national datasets (e.g., the Health and Retirement Study, Brown et al., 2020; Midlife in the United States (MIDUS), Slopen et al., 2018). In the Coronary Artery Risk Development in Young Adults Study and Health and Retirement Study, for example, participants are asked to complete a checklist of domains of life (e.g., financial, relationship, work) in which they may be experiencing stress or difficulties for at least 6 months or 1 year, respectively, and the extent to which these chronic stressors are stressful or upsetting on a scale from 1 (*yes, not very stressful/upsetting*) to 3 (*yes, extremely stressful/upsetting*). In MIDUS, cumulative stress is typically scored by combining standardized results from eight different single-domain measures of chronic stressor exposures and perceptions of how difficult, stressful, or threatening these exposures are (Williams & Slopen, 2019). Each stressor domain—relationship, financial, work, negative work-family spillover, perceived deprivation, neighborhood, discrimination, and past year family problems—has previously been established as a health-relevant stressor (e.g., Block et al., 2009; Cuevas et al., 2019; Slopen et al., 2013). The cumulative stress measure has been presented in several previous works (e.g., Albert et al., 2017; Lockwood et al., 2022; Slopen et al., 2018).

Due to its additive nature and resting on principles from life course theories (e.g., Lupien et al., 2009; Slavich, 2016; Slopen et al., 2018), cumulative stress may be more strongly associated with health outcomes, above and beyond the experience of chronic stress within single domains of life (Evans et al., 2013; Evans & Kim, 2010; Mann et al., 2021; Turner & Lloyd, 1995). Previous research has documented positive cross-sectional and prospective associations between increasing levels of cumulative stress and indicators of poor health and well-being, including unhealthy behaviors such as smoking (Albert et al., 2017; Slopen et al., 2012) and food addiction (McMullin et al., 2021), more daily health symptoms (albeit in an adolescent sample; Rehna et al., 2016), presence of disease and mental illness (Albert et al., 2017; Burroughs Peña et al., 2019), and long-term telomere attrition (Cabeza de Baca et al., 2020). Furthermore, in line with the notion that exposure to multiple

stressors versus a single stressor is more strongly associated with poor health (Evans et al., 2013; Evans & Kim, 2010; Slopen et al., 2018; Turner & Lloyd, 1995), cumulative stress has been shown to be more strongly related to current smoking status (Slopen et al., 2012) and allostatic load (Reading et al., 2016) than chronic stress in a single domain. Cumulative stress has also been associated with disparities in obesity (Cuevas et al., 2020) and cognitive function (Chen et al., 2022) between ethnic minorities (e.g., Black, Hispanic) and Whites in the United States.

Daily Stressor Exposure and Daily Health

According to the Transdisciplinary Model of Stress (Epel et al., 2018), one's daily stress processes, including the occurrence of a daily stressor and acute physiological responses (e.g., expressed physical symptoms), are influenced by one's history and background, including levels of "cumulative stress." Thus, cumulative stress across multiple life domains is presumed to partly worsen health and well-being by altering the frequency of daily-level exposure to stressful events and their effects on daily health and well-being. Daily stressors can be defined as relatively minor events which are a nuisance and emerge from everyday living (e.g., deadlines, arguments, traffic; Almeida, 2005). Whereas chronic stressors are life challenges that are persistent and ongoing, daily stressors are subjectively smaller and more discrete events which emerge from everyday living (DeLongis et al., 1988). Compared with chronic stressors, daily stressors have a more immediate and short-lived effect on health and well-being, both psychologically and physiologically (for review see Almeida et al., 2011). It has previously been reported that individuals who report greater exposure to chronic stressors within specific and across multiple life domains have an increased likelihood of reporting more daily stressors within and across those domains (e.g., Crosswell et al., 2020; Lockwood et al., 2022). Experiencing a daily stressor is associated with increased daily physical symptoms (such as headaches, nausea, and cold symptoms) compared to days without stressors (DeLongis et al., 1988; Hill et al., 2018). Daily physical symptoms are themselves important for health, as prior research demonstrates that individuals who report more daily symptoms have a worse negative affect (Charles & Almeida, 2006), and an increased risk of reporting chronic conditions (e.g., pain conditions, autoimmune disorders) and functional disability 10 years later (Leger et al., 2015).

The Present Research

While the association between cumulative stress across multiple domains and health is well established (e.g., Albert et al., 2017; McMullin et al., 2021), the extent to which cumulative stress compounds associations between reporting of a stressful event and elevations in physical health symptoms is unknown. Given that others have found that daily stressors are associated with increased daily symptoms (DeLongis et al., 1988; Hill et al., 2018), and accounting for recent work that suggests that cumulative stress compounds daily well-being on days with (vs. without) stressors (Lockwood et al., 2022), it is hypothesized that cumulative stress will compound reports of physical symptoms. Specifically, we hypothesized that (a) high cumulative stress would be associated with increased reports of and more severe daily physical symptoms, (b) days with stressors, compared with days without stressors, will be associated with increased

reporting of and severity of physical symptoms, and (c) increased reports and severity of daily symptoms occurring on days with, as compared to days without stressors, would be exacerbated for individuals with higher levels of cumulative stress.

Method

Participants and Procedure

The present work employed national data, collected from 2004 to 2009, as part of the second MIDUS Study. The analytic sample ($N = 2,022$; 57.22% female; 84.22% White; 96.74% non-Hispanic; 71.76% married or in a marriage-like relationship; 87.98% had at least one child; 66.77% employed; 45.35% with some postsecondary education) included midlife American adults (aged from 35 to 86; $M_{\text{age}} = 56$) who completed both the MIDUS II survey and at least one interview from the National Study of Daily Experiences (NSDE). Information on recruitment, eligibility, and response rates, as well as differences between the MIDUS II survey and NSDE samples, can be found in the online [supplemental materials](#). Individuals who provided informed consent completed a self-administered survey (MIDUS II), and at least 3 months later were contacted on eight consecutive days to report on daily-level experiences in a 30-min telephone interview (NSDE). This procedure was approved by Research Ethics Boards at the University of Wisconsin–Madison and The Pennsylvania State University.

Measures

Cumulative Stress

Using scales from the MIDUS II survey, participants rated their stressor exposures and perceptions as experienced across eight life domains: relationship stress was measured using 19 items across four subscales (family strain, friend strain, spouse/partner strain, and marital risk); financial stress was measured using two items; psychological and physical work stress was measured using 29 items across seven subscales (skill discretion, decision authority, job demands, coworker nonsupport, supervisor nonsupport, occupational physical strain, and risk of injury); negative spillover was measured using eight items across two subscales (work-to-family spillover, family-to-work spillover); perceived deprivation was measured using 18 items across three different subscales (home/neighborhood, work, family; previously labeled perceived inequality in [Mann et al., 2021](#); [Slopen et al., 2018](#)); neighborhood stress was measured using four items; discrimination was measured using 26 items across three different subscales (lifetime, daily, and job); and immediate family problems experienced within the last year was measured using 30 items across three different subscales (spouse/partner, parents, and children). Exact items and Cronbach's alphas for each scale/subscale have been included in the online [supplemental materials](#). In accordance with MIDUS suggestions ([Williams & Slopen, 2019](#)), whenever a life stress measure was irrelevant to a participant based on demographics, missing data (0%–22%) were replaced with the lowest value possible (sequential multiple imputation was used to control for missing data which may have not been random; [Raghunathan et al., 2001](#)). Scores from each measure were standardized and summed, and then the summed measure was standardized to create a standardized composite score, such that higher scores represented higher cumulative stress.

Daily Stressors

Using the daily inventory of stressful events ([Almeida et al., 2002](#)), each day during the NSDE, participants indicated whether they had experienced any daily stressors (0 = *no*, 1 = *yes*) from seven stressor domains: arguments, avoiding arguments, work/school stressors, home stressors, network stressors, discrimination, and any other stressors. In accordance with previous work using the same data (e.g., [Lockwood et al., 2022](#); [Slopen et al., 2013](#)), and given that 90% of days participants reported at most one stressor, responses were coded to indicate the presence versus absence of daily stressors (1 = *at least one stressor*, 0 = *no stressor*).

Daily Physical Health Symptoms

Each evening, participants indicated whether they had experienced any of 28 health symptoms during the past 24 hr (0 = *no*, 1 = *yes*; adapted from [Larsen & Kasimatis, 1991](#)). Symptoms included headache, backache, muscle soreness, fatigue, joint pain, muscle weakness, cough, sore throat, fever, chill, other cold/flu symptoms, nausea, allergies, diarrhea, constipation, poor appetite, other stomach problems, chest pain, dizziness, shortness of breath, menstrual related symptoms, hot flashes or flushes, skin-related symptoms, eye-related symptoms, ear-related symptoms, teeth-related symptoms, leg/foot-related symptoms, and other physical symptoms. Scores were summed, such that higher scores indicated more daily health symptoms. Responses were also coded to indicate the presence versus absence of daily symptoms (0 = *no symptoms*, 1 = *at least one symptom*). The severity of each symptom experienced was further rated on a 10-point scale ranging from 1 (*very mild*) to 10 (*very severe*); responses were averaged, such that higher scores indicated higher daily symptom severity.

Covariates

Following [Lockwood et al. \(2022\)](#), sociodemographic covariates included sex, age, race, ethnicity, education, employment status, marital status, parental status, and presence of a sibling in the sample. In line with the Transdisciplinary Model of Stress ([Epel et al., 2018](#))—in which health behaviors are proposed to influence the associations between chronic stress, daily stressors, and biological aging—physical activity status and daily smoking were also included as covariates in a subsequent step. The importance of including such health behaviors as covariates is further demonstrated by past MIDUS research which conveyed physical activity/smoking as being associated with cumulative stress, as well as with psychological responses to daily stressors ([Puterman et al., 2017](#); [Slopen et al., 2012](#)). Furthermore, since experiencing chronic health conditions is associated with higher reports of cumulative and daily stressor exposures (e.g., [Albert et al., 2017](#); [Piazza et al., 2007](#)) and is inherently related to daily physical symptoms, we included number of chronic health conditions experienced in the past year as a covariate in each analysis. Lastly, we included the percent of days with a reported stressor as a covariate to control for differential response rates. Categorization and coding of each covariate are discussed in [Table 1](#) footnote.

Analytic Plan

Data were analyzed using SPSS Version 27. Descriptive statistics were calculated for all study variables and covariates. Whereas

Table 1*Multilevel Models for Cumulative Stress and Daily Stressor Exposure Predicting Number of Physical Symptoms*

Parameter	Model 1					Model 2					Model 3				
	B	SE	95% CI		p	B	SE	95% CI		p	B	SE	95% CI		p
			Lower	Upper				Lower	Upper				Lower	Upper	
Intercept	1.23	0.22	0.81	1.66	<.001	1.05	0.21	0.64	1.47	<.001	1.22	0.22	0.79	1.65	<.001
Cumulative stress	0.15	0.05	0.06	0.24	<.001	—	—	—	—	—	0.10	0.05	<0.01	0.19	.039
Stressor day (Y/N)	—	—	—	—	—	0.31	0.03	0.26	0.36	<.001	0.31	0.03	0.26	0.36	<.001
Cumulative Stress × Stressor Day (Y/N)	—	—	—	—	—	—	—	—	—	—	0.13	0.03	0.07	0.18	<.001

Note. Unstandardized regression coefficients (*B*s) are shown by predictor (row) variable, along with 95% confidence intervals (CIs) and *p*-values. Each model adjusted for a series of covariates including age (centered), sex (−1 = male, 1 = female), education (0 = less than high school, 1 = high school or equivalent, 2 = college, 3 = postgraduate), ethnicity (−1 = non-Hispanic, 1 = Hispanic), race (0 = Other, 1 = Black, 2 = White), employment status (0 = not currently working, 1 = currently working), parental status (0 = childless, 1 = one or more children), marital status (0 = unmarried/not living with partner, 1 = married or living in a marital-like relationship), sibling status (0 = no sibling, 1 = sibling/twin), activity status (0 = inactive/guidelines not met, 1 = active/met CDC physical activity guidelines), smoking status (−1 = nonsmoking day, 1 = smoking day), and percent of days with a reported stressor (as a proportion of completed interview days).

associations between continuous variables were calculated using Pearson correlations, differences between continuous and dichotomous/polytomous variables were analyzed using *t*-tests or analysis of variance tests. To determine whether there was significant within-person variation in the number and severity of physical symptoms, intraclass correlation coefficients were calculated using unconditional mixed linear (MIXED syntax) models.

Hypotheses were tested using multilevel models with two levels (Level 1 = within-subjects, Level 2 = between-subjects). For each hypothesis, we first included the hypothesized independent variable only (e.g., cumulative stress), then sequentially added covariates as additional predictors in subsequent models. We report on final models controlling for all covariates (sociodemographic, health behavior, chronic condition, and percent of days with reported stressors). To evaluate Hypothesis 1, the extent to which cumulative stress was associated with increased odds of reporting daily physical symptoms, a generalized linear mixed model (GENLINMIXED syntax) with binary logistic regression (logit linked) was conducted. Further, mixed model (MIXED syntax) regressions were used to analyze whether higher reports of cumulative stress would predict an increased number and severity of daily symptoms. For exploratory purposes, each individual domain was also analyzed as a predictor of daily symptoms (see Tables S4–S6 in the [online supplemental materials](#)), corrected for the false discovery rate (Benjamini & Hochberg, 1995).

Similarly, a generalized linear mixed model (GENLINMIXED syntax) with binary logistic regression (logit linked) was used to test Hypothesis 2—whether the odds of reporting daily symptoms increased on days with stressors as compared to days without stressors. Whether daily stressor exposure would predict an increased number and severity of daily physical symptoms were tested using mixed model (MIXED syntax) linear regressions.

Moreover, to test Hypothesis 3 a generalized linear mixed model (GENLINMIXED syntax) with binary logistic regression (logit linked) was performed. The odds of reporting a daily symptom were regressed simultaneously onto daily stressor (yes/no; Step 1), cumulative stress (Step 2), and the interaction between daily stressor exposure and cumulative stress (Step 3). Further, in two separate mixed models (MIXED syntax) with random intercepts, fixed slopes, and restricted likelihood estimation, number, and severity of physical symptoms were regressed simultaneously onto daily

stressor (yes/no; Step 1), cumulative stress (Step 2), and the interaction between daily stressor exposure and cumulative stress (Step 3). Each moderation analysis was further conducted at one standard deviation above and below the cumulative stress mean.

The variance accounted for in the odds, number, or severity of daily physical symptoms (*Y*) by presence versus absence of a daily stressor (*X*), cumulative stress (*Z*), and the interaction of *X* and *Z* was predicted using Mixed syntax. Beta coefficients are produced for the intercept (*B*₀), *X*, *Z*, and the interaction (*X***Z*). Average physical symptoms on days without reported stressors are represented by *B*₀ at average cumulative stress. The approximate difference in physical symptoms on days with reported stressors as compared with *B*₀ at average reported cumulative stress is represented by *B*_{stressor day}, while *B*_{stressor day} added to *B*₀ is the approximate mean physical symptoms on days with reported stressors. The approximate difference in physical symptoms from their estimated average at a one-unit change in cumulative stress on days without stressors as compared with *B*₀ is represented by *B*_{cumulative}. The difference in average physical symptoms on days with (vs. without) reported stressors at a one-unit change in cumulative stress is represented by *B*_{interaction}.

Results

Descriptive statistics are shown in Table 2. Higher reported cumulative stress was associated with younger age ($r = -.43, p < .001$), more chronic conditions ($r = .17, p < .001$), a greater number of stressor days ($r = .23, p < .001$), and more days with physical symptoms ($r = .06, p = .007$). Cumulative stress was significantly higher for participants who identified as Black, $F(2, 2,015) = 33.62, p < .001$, did not have a sibling in the sample, $t(2,020) = 2.83, p = .005$, obtained less than high school education, $F(3, 2,017) = 6.42, p < .001$, and were physically inactive, $t(2,020) = 2.05, p = .041$, and was significantly lower for those not working, $t(2,015) = -14.33, p < .001$, and not smoking, $t(1,840) = -6.10, p < .001$.

Nearly all participants (89.71%) reported experiencing a stressor on at least one of the eight interview days. Reporting a higher number of stressor days was associated with younger age ($r = -.19, p < .001$), more chronic conditions ($r = .08, p < .001$), more days with physical symptoms ($r = .27, p < .001$), and higher average

weekly symptom severity ($r = .14, p < .001$). The number of days with a reported stressor was significantly higher for those who identified as White, $F(2, 2,013) = 9.72, p < .001$, and those with postgraduate education, $F(3, 2,014) = 32.26, p < .001$, and was significantly lower for males, $t(2,020) = -3.80, p < .001$, those who were unmarried, $t(2,020) = -2.31, p = 0.21$, and those not working, $t(2,015) = -6.88, p < .001$.

Similarly, almost all participants (94.11%) reported a physical symptom on at least one of the eight interview days. Reporting a higher number of days with physical symptoms was associated with older age ($r = .08, p < .001$), more chronic conditions ($r = .32, p < .001$), and higher average weekly symptom severity ($r = .69, p < .001$). The number of days with a reported symptom was significantly higher for those who identified as White, $F(2, 2,013) = 3.75, p = .024$, and those not working, $t(2,015) = 6.54, p < .001$, and was significantly lower for males, $t(2,020) = -6.33, p < .001$, and nonsmokers, $t(1,840) = -1.95, p = .05$.

Higher average weekly symptom severity was associated with older age ($r = .08, p < .001$) and more chronic conditions ($r = .40, p < .001$). Average weekly symptom severity was significantly higher for those who identified as Black, $F(2, 2,013) = 10.92, p < .001$, unmarried, $t(2,020) = 3.64, p < .001$, not working, $t(2,015) = 9.67, p < .001$, had less than a high school education, $F(3, 2,014) =$

18.47, $p < .001$, those without a sibling in the sample, $t(2,020) = 3.82, p < .001$, and those who were inactive, $t(2,020) = 3.35, p < .001$, and was significantly lower for males, $t(2,020) = -8.91, p < .001$, and nonsmokers, $t(1,840) = -3.54, p < .001$.

Cumulative Stress and Daily Symptoms

The unconditional model demonstrated significant within-person variation across days in the number (32.76% variation; ICC = 0.67, $p < .001$) and severity (54.05% variation; ICC = 0.46, $p < .001$) of physical symptoms; enough within-person daily variation to use mixed models. Adjusting for covariates, a generalized linear mixed model indicated that greater odds of reporting daily physical symptoms were predicted by higher cumulative stress, ($OR = 1.12, p = .016$, such that those who reported a one-unit increase in cumulative stress were 12% more likely to report a daily symptom on a given day. Similarly, both higher number and severity of daily physical symptoms were independently predicted by higher levels of cumulative stress ($B = 0.15, p < .001, B = 0.10, p = .005$, respectively).

Daily Stressor Exposure and Daily Symptoms

Increased odds of reporting a daily symptom were independently predicted by the presence (vs. absence) of a daily stressor ($OR = 1.45, p < .001$). That is, individuals reported a 45% increase in the odds of reporting a daily physical symptom on days with a reported stressor as compared with days without stressors. Likewise, both the higher number and severity of daily symptoms were independently predicted by the presence (vs. absence) of a daily stressor ($B = 0.31, B = 0.25, ps < .001$, respectively). All results controlled for sociodemographic characteristics, health behaviors, presence of chronic conditions, and percent of stressor days.

Combined Effects of Cumulative Stress and Daily Stressor Exposure

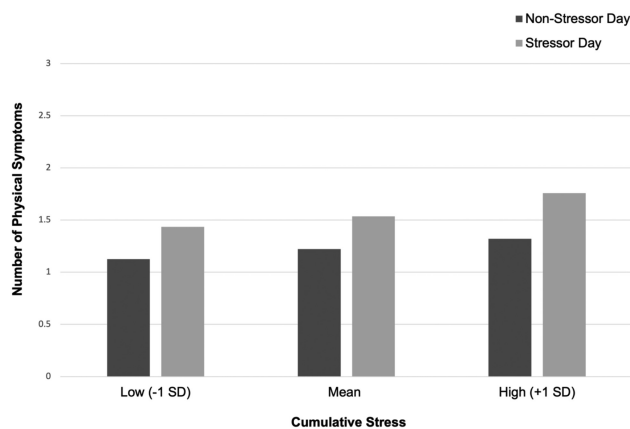
After adjusting for all covariates, cumulative stress significantly interacted with daily stressor exposure to predict the odds ($OR_{interaction} = 1.18, p = .002$), number ($B_{interaction} = 0.13, p < .001$), and severity ($B_{interaction} = 0.07, p = .009$) of daily physical symptoms (see Table 1 and Figures 1–3, as well as Tables S1–S2 in the online supplemental materials). At mean levels of cumulative stress, the odds of reporting, as well as the number and severity of physical symptoms, were higher on days with (vs. without) reported stressors ($OR_{stressorday} = 1.48, B_{stressorday} = 0.31, B_{stressorday} = 0.25, ps < .001$, respectively). At high cumulative stress scores (1 $SD >$ mean), there was a 1.75 increase in the odds of reporting a daily symptom on days with a stressor compared with nonstressor days, whereas at low cumulative stress scores (1 $SD <$ mean), there was a 1.25 increase in the odds of reporting a daily symptom on days with a stressor compared with nonstressor days. These effects were not driven by any physical health outcome in particular, as analyses investigating the interactions of cumulative stress and daily stressor exposure on each of the four most frequent daily health outcomes (i.e., joint pain, muscle soreness, fatigue, and backache) were not significant (see Table S3 in the online supplemental materials). The number and severity of daily symptoms increased on days with (vs. without) stressors by 0.44 and 0.33 at 1 SD above, and 0.19 and 0.18 at 1 SD below, the average cumulative stress,

Table 2
Descriptive Statistics for the Full Sample ($N = 2,022$)

Age, M (SD)	56.24	12.20
Sex, N (%)		
Female	1,157	57.22
Male	865	42.78
Education, N (%)		
<High school	128	6.33
High school or equivalent	973	48.12
College completed	538	26.61
Postgraduate	379	18.74
Race, N (%)		
White	1,703	84.22
Black	228	11.28
Other	85	4.20
Ethnicity, N (%)		
Hispanic	60	2.97
Non-Hispanic	1,956	96.74
Marital status, N (%)		
Married or marriage-like relationship	1,451	71.76
Not married	571	28.24
Employment, N (%)		
Currently employed	1,350	66.77
Currently unemployed	667	32.99
Parental status, N (%)		
1+ Child	1,779	87.98
0 Children	243	12.02
Sibling status, N (%)		
Sibling/twin	701	34.67
Not sibling/twin	1,321	65.33
Activity status, N (%)		
Active	1,077	53.26
Underactive	945	46.74
Smoking status, N (%)		
Smoker	229	11.33
Nonsmoker	1,613	79.77
Number of chronic conditions, M (SD)	2.54	2.48
Stressor days, M (SD)	2.87	1.95
Days with symptoms, M (SD)	4.93	2.67
Weekly symptom severity, M (SD)	2.60	1.37

Figure 1

Estimate of Number of Symptoms on Days With Versus Without Stressors by Cumulative Stress



Note. The number of physical symptoms measure ranged from 0 to 28. Number of symptoms was significantly (i.e., $p < .05$) higher on days with (vs. without) stressors at low, mean, and high levels of cumulative stress.

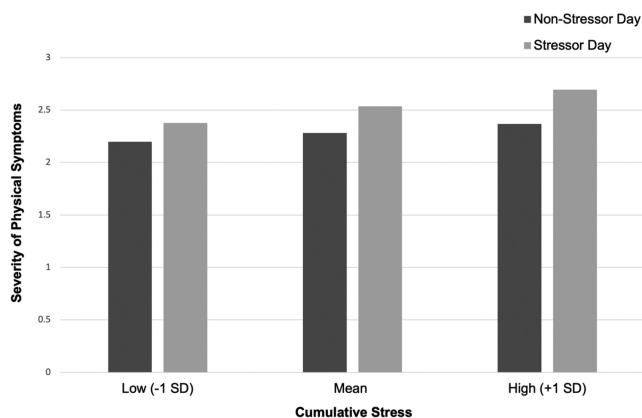
respectively. Thus, worse reports of daily physical symptoms occurring on days with, as compared with days without stressors, were further potentiated at higher levels of cumulative stress.

Exploratory Analyses

Each independent stressor domain was also tested as a direct predictor of the three outcomes (number, severity, and odds of daily symptoms), with corrections for the false discovery rate applied to each outcome's set of analyses (see Tables S4–S6 in the [online supplemental materials](#)). As results indicated that financial stress and perceived deprivation in home/neighborhood, family, and work-life were significantly associated with two of the three outcomes following correction

Figure 2

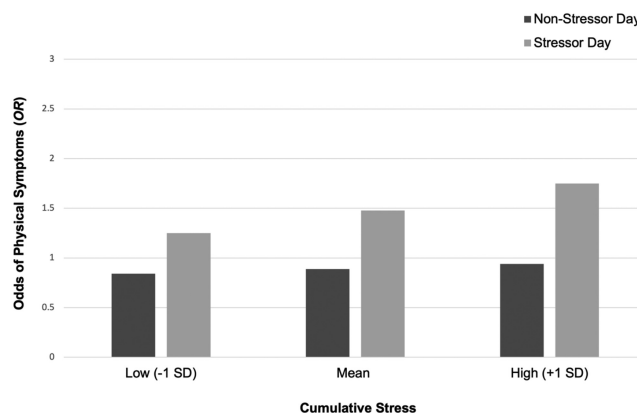
Estimate of Severity of Symptoms on Days With Versus Without Stressors by Cumulative Stress



Note. Symptom severity was rated on a scale of 1 (*very mild*) to 10 (*very severe*). Severity of symptoms was significantly (i.e., $p < .05$) higher on days with (vs. without) stressors at low, mean, and high levels of cumulative stress.

Figure 3

Estimate of Odds of Symptoms on Days With Versus Without Stressors by Cumulative Stress



Note. OR = odds ratio, the odds that a physical symptom will be reported on days with (vs. without) a daily stressor exposure. Odds that a physical symptom would be reported were significantly (i.e., $p < .05$) higher on days with (vs. without) a daily stressor exposure at low, mean, and high levels of cumulative stress.

for the false discovery rate, we conducted two sets of additional unplanned exploratory analyses: (a) financial stress and perceived deprivation combined and (b) all other stress domains combined, as a predictor of the three outcomes. These exploratory analyses suggest that financial stress and perceived deprivation across multiple domains account largely for the direct effects on daily number, odds, and severity of physical symptoms (see Table S7 in the [online supplemental materials](#)). Next, we also explored whether the two reduced cumulative stress measures interacted with daily stressor occurrence to predict the daily number, odds, and severity of physical symptoms (see Table S8 in the [online supplemental materials](#)). Results revealed that these two reduced iterations of cumulative stress significantly moderated the effects of daily stressor occurrence on daily physical symptoms.

Discussion

The objective of the present research was to determine how cumulative stress and daily stressor exposure interact to predict daily reports of physical health symptoms (e.g., headache, backache, nausea). Results showed that higher cumulative stress was independently associated with higher odds, number, and severity of daily physical symptoms. Exploratory results indicate that these effects are predominantly driven by financial stress and perceptions of being relatively deprived of pride and opportunities in family, home/neighborhood, and work-life. In a second set of analyses, days with a reported stressor (compared with nonstressor days) were also independently associated with higher odds, number, and severity of daily physical symptoms. Moreover, the negative effects of experiencing a daily stressor on daily physical symptoms were worse for those with greater cumulative stress, and these effects were not only restricted to financial stress and perceptions of deprivation in family, home/neighborhood, and work life. All findings remained significant when accounting for associated sociodemographic covariates, health behaviors, number of chronic conditions,

and percent of days with a reported stressor, suggesting the robustness of the results.

Cumulative Stress and Daily Symptoms

Individuals who experienced and perceived higher (i.e., a one-unit increase in) recent and historical chronic stress across multiple domains of life were 12% more likely to report experiencing daily symptoms. When restricted to a combination of financial difficulties and perceived deprivation in family, home/neighborhood, and work-life, participants were 11% more likely to report experiencing daily symptoms. This extends past work highlighting the positive relationship between greater cumulative stress and poorer health and well-being (e.g., Albert et al., 2017; Cabeza de Baca et al., 2020), by providing evidence that chronic stress experienced across multiple domains is related to physical health on a daily level. Such a finding has been demonstrated in the past among a sample of adolescents (Rehna et al., 2016), however, to our knowledge, this is the first study to show that cumulative stress (as measured here) predicts daily symptoms within a large national sample of midlife adults. This finding emphasizes the value of measuring chronic stress as accumulated over time across multiple domains (e.g., Evans et al., 2013; Slopen et al., 2018), rather than limiting measures to discrete experiences.

However, our exploratory results indicated that perhaps fewer items might be appropriate when conceptualizing cumulative stress across multiple domains, at least in terms of direct relationships with number and severity of daily physical symptoms. Financial stress and perceptions of being deprived of pride and opportunities in family, home, neighborhood, and work domains may capture the breadth of cumulative stress necessary to investigate the impact of cumulative stress on daily health compared with a more comprehensive measure as completed in our primary analyses. Revising previous analyses on health (Cabeza de Baca et al., 2020; Rehna et al., 2016) and well-being (Albert et al., 2017; Cuevas et al., 2020), as well as health behaviors (Albert et al., 2017; McMullin et al., 2021; Slopen et al., 2012), using the individual domains and comparing results with the cumulative stress measure currently being used might help clarify the most parsimonious set of domains needed to understand the impact of cumulative stress on health and well-being. Such refinement may also reduce the burden on participants completing questionnaires in large national studies seeking to understand the impact of cumulative stress on health and well-being. It is also important to note that the “lumping” of all these measures across the multiple domains may be cause for concern, especially due to the inconsistency in time frames across the measures. A recent study utilizing this wide set of measures was evidenced to fit well into five broader domains of discrimination, home and work, relationship, financial, and perceived deprivation, which also collectively fit well into a higher-order unidimensional “s” factor (Mann et al., 2021). Further exploration and refinement of cumulative stress as a concept along the dimensions of exposures/domains, responses, and timeframes (Epel et al., 2018) should be completed.

o why might experiencing high cumulative stress predict worse daily health outcomes? One possibility is that repeated exposure to stressors which have persisted over time, as well as the perceived psychological burden of such exposures, can lead to repeated activation of physiological stress systems. More specifically, repetitive and accumulated chronic stress over time can lead to prolonged hyperarousal of the cardiovascular, metabolic, immune, and central

nervous systems, resulting in higher allostatic load (Lupien et al., 2009; McEwen, 1998). The prolonged activation of such systems causes their function to deteriorate, resulting in many health consequences, including those captured at the daily level (e.g., pain and fatigue; Cacioppo et al., 2000; McEwen, 1998). Future work is needed to probe the physiological mechanisms underlying cumulative stress and its association with poor daily health.

Daily Stressors and Daily Symptoms

Experiencing a daily stressor (e.g., argument, work stressor) increased one's likelihood of reporting a daily symptom by 45%, and independently predicted a greater number and more severe daily somatic health symptoms. Such findings align with past work which highlights the significance of daily stressors for daily physical health (DeLongis et al., 1988; Hill et al., 2018). However, we extend this work by showing that participants within the NSDE sample not only report a higher *number* of physical symptoms on days with (vs. without) a reported stressor, but also report greater *odds* of experiencing daily symptoms, as well as greater *severity* of such symptoms. This is critical, as the severity of daily physical symptoms is uniquely predictive of one's physical health and well-being over the long term (e.g., Bair et al., 2003).

One way in which daily stressor exposure may lead to worse daily physical symptoms is through elevated physiological arousal. For example, at the daily level, daily stressor exposure has been associated with increased cortisol (Smyth et al., 1998), elevated catecholamine, increased prolactin, and low heart rate variability (Chandola et al., 2010). This dysregulation of pro-inflammatory proteins (signaling an exaggerated pro-inflammatory response) has been associated with exaggerated pain (for review see Watkins & Maier, 2000), and is a possible pathway in which elevated physiological arousal may lead to worse daily health. In addition, cognitive responses to acute stressors may also help to explain the association between daily stressor exposure and worse daily health (Epel et al., 2018). Specifically, cognitively and affectively managing the experience of and response to daily stressors may monopolize valuable psychological resources which are needed to help manage one's experiences of daily health symptoms and their severity. Moreover, the taxing cognitive demand associated with managing daily stressors in and of itself may also lead to poorer physiological responses, such as increased blood pressure, heart rate, and cortisol levels (Lavallo & Thomas, 2000; Wright & Kirby, 2001). Perseverative cognitions especially may draw out one's initial physiological response to a stressor, and may lead to an inability to return to homeostasis (Smyth et al., 2013). Thus, to further disentangle why worse symptoms may occur on days with (vs. without) stressors, daily physiological arousal and cognitive responses to stressors should be measured and examined in relation to daily stressor exposure and daily symptoms.

Moderating Role of Cumulative Stress

In support of Hypothesis 3, we found that the negative implications of daily stressor exposure for daily physical health were amplified for individuals characterized by worse perceived past and recent stress across multiple domains of life. Thus, not only does perceiving greater cumulative stress increase one's chance of experiencing a daily stressor (e.g., Epel et al., 2018; Lockwood et al., 2022), but our results suggest that those who report higher cumulative stress

experience worse daily health as predicted by daily stressor exposure (i.e., a greater psychosomatic response). To our knowledge, this is the first study to use a measure of chronic stress that accounts for stressor exposure and appraisal across multiple life domains to demonstrate this interaction. These effects were consistent when the cumulative stress measure included all of the measures included in previous studies (e.g., Lockwood et al., 2022; Mann et al., 2021; Slopen et al., 2018), or was limited to financial difficulties and perceived deprivation in family, home/neighborhood, and work life, or a cumulative stress measure without these two measures.

This finding lends support to the life course models of stress (e.g., Lupien et al., 2009; Slavich, 2016), whereby accumulated chronic stress is hypothesized to influence health by changing one's daily stress experiences and the effect of such experiences on daily health and well-being. Accordingly, cumulative stress may act as an individual difference which influences how one habitually responds to daily stressors, above and beyond other known protective factors such as an active lifestyle. For example, those who have experienced high chronic stress across multiple domains may be conditioned to perceive and respond to future stressors as more of a threat than a challenge. Such individuals are more likely to appraise everyday demands as exceeding their resources, which is associated with poorer physiological responses, cardiovascular reactivity, and biological aging (Blascovich & Mendes, 2010; O'Donovan et al., 2012). In addition, high cumulative stress may change one's neural pathways resulting in dysregulated physiological reactions to daily stressors (Epel et al., 2018; Lupien et al., 2009). Future research should examine appraisals of daily stressors in order to examine if levels of cumulative stress alter one's habitual appraisal pattern, and whether this has implications for daily health. Furthermore, future studies should examine neurophysiological and affective measures over time in relation to the variables in question.

Moderation results in the current study align with Lockwood et al. (2022) findings that cumulative stress compounded the relationship between daily stressor exposure and daily negative affect. More specifically, Lockwood et al. (2022) found that those with high (vs. low) cumulative stress experienced a greater negative affect on days with (vs. without) reported stressors. It is important, then, to examine whether greater negative affect experienced on stressor days stemming from high cumulative stress could act as a mediator helping to explain the interaction effect of cumulative stress and daily stressor exposure on daily physical symptoms. Accordingly, changes in a negative affect on days with (vs. days without) a stressor could be added to future models.

Importantly, as argued by Smyth et al. (2013), the relationship between chronic stressors and daily stressor exposure may be bidirectional. That is, one may be more likely to report experiencing chronic stressors when frequently (vs. infrequently) exposed to daily stressors. Moreover, the odds of experiencing chronic stressors may be increased for those who do not psychologically and/or physiologically adapt well to daily stressors. However, in MIDUS, cumulative stress was measured prior to daily stressor exposure, and thus this bidirectionality cannot be teased apart.

Nonetheless, the strength of our findings is further highlighted by the fact that all effects remained significant after adding relevant covariates into the model in subsequent steps. This is important, as it shows that cumulative stress and the presence of a daily stressor interact to predict daily health above and beyond protective factors (i.e., physical activity) hypothesized to buffer or compound the

negative effects of stressors on health (Epel et al., 2018). Further, by controlling for covariates which are known to be associated with daily physical symptoms (e.g., smoking, chronic conditions; Slopen et al., 2012), we were able to better isolate the magnitude of the independent predictive effects of daily stressors exposure, cumulative stress, and their interaction. Lastly, although we were able to control for the predictive effects of sociodemographic characteristics on daily symptoms, such differences provide contextual background when measuring present and historical experiences of stress and should be examined as moderators in future analyses.

Limitations and Future Directions

In addition to the above-mentioned considerations, a major limitation of the present study was that most of the participants (84.22%) included in the sample identified as being White. In addition to this limiting the representativeness of the present findings, there are identified racial and ethnic disparities in exposure to, and appraisal of, cumulative and chronic stressors (Brown et al., 2020). For example, Brown et al. (2020) found that Black Americans, U.S.-born Hispanic adults, and foreign-born Hispanic adults report greater exposure to stressors than Whites, yet appraise such stressors as being less upsetting. Reports of cumulative stress, as well as the significance of such reports for daily physical health, may likely differ between racial and ethnic groups as well, emphasizing the importance of improving recruitment and inclusion of underrepresented groups. Using a more representative sample, it would be important to examine the moderating roles of race and ethnicity in the context of the objectives of the present study. Additionally, females in the current study reported a greater number of days with a reported stressor, in line with previous work (Davis et al., 2010). Future work should examine sex and gender as not only covariates, but as potential moderating factors of the associations revealed in the current study.

Furthermore, the relationship between high cumulative stress and worse daily symptoms may be stronger for those who report lower social support and thus fewer social resources that can be used to mitigate the negative implications of high cumulative stress for daily health (Pearlin et al., 2005; Wheaton, 2009). This is evidenced by laboratory studies, wherein greater social support has been shown to buffer the negative consequences of psychological stress for cardiovascular and cortisol reactivity (Thorsteinsson & James, 1999). It would be valuable to examine social support in relation to cumulative stress and daily symptoms to further illustrate how social support inequality is somatized on a daily basis.

Additionally, in the present work, we only examined cumulative stress and daily domains of stress. However, there are many other types of stressors with different exposures, responses, and timeframes (e.g., early life exposure to adversity, major life events), that should be examined in relation to daily health in future work. Although the domains within the cumulative stress composite score were selected by MIDUS investigators due to their relevance to the sample and operational alignment with the broad theorized concept of cumulative stress, it would be valuable to conduct a Delphi review with experts to further refine how the construct is operationalized.

Finally, when considering such pathways connecting daily stressor exposure and poor daily physical symptoms, it is important to bear in mind that we were unable to determine the temporal order in which participants experienced daily stressors and physical symptoms. It may be that participants experienced daily physical

symptoms prior to experiencing a daily stressor. In the future, it would be valuable to utilize experience sampling multiple times per day to gather real-time data regarding one's exposure to daily stressors and subjective physical health experiences, allowing for temporal certainty and thus more causal conclusions.

Conclusion

This was the first study to examine the extent to which cumulative stress compounds associations between reporting a stressful event and associated elevations in physical health symptoms. Using national data collected from midlife adults, we found that both high cumulative stress and presence of a daily stressor independently predicted higher odds, number, and severity of daily physical health symptoms. Moreover, the negative implications of experiencing a daily stressor for reports of daily symptoms were further potentiated at higher levels of cumulative stress. This finding highlights the importance of measuring chronic stress as experienced across multiple life domains and temporal periods, as argued by Epel et al. (2018). Further, our findings lend support to the Transdisciplinary Model of Stress (Epel et al., 2018) by demonstrating that cumulative stress may influence health by altering one's daily stressor exposures and the associations of such experiences with daily health. Overall, our findings highlight the importance of intervening with populations who may be at increased risk of perceiving high cumulative stress, to promote and foster resilience to daily stressors.

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