

Daily Stressors and Adult Day Service Use by Family Caregivers: Effects on Depressive Symptoms, Positive Mood, and Dehydroepiandrosterone-Sulfate

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Objective: *This study examines effects of daily use of adult day service (ADS) programs by caregivers of individuals with dementia (IWD) on a salivary biomarker of stress reactivity, dehydroepiandrosterone-sulfate (DHEA-S), and whether these effects on DHEA-S are associated with daily variability in positive mood and depressive symptoms. **Methods:** We used a daily diary design of 8 consecutive days with alternation of intervention (ADS) and nonintervention days to evaluate within- and between-person effects of the intervention. Family caregivers (N = 151) of IWD who were using ADS were interviewed daily by telephone at home. Saliva samples were collected from caregivers five times a day for 8 consecutive days and were assayed for DHEA-S. Daily telephone interviews assessed daily stressors and mood. **Results:** DHEA-S levels were significantly higher on days after ADS use. Daily DHEA-S levels covaried significantly with daily positive mood but not with depressive symptoms. **Conclusion:** These results demonstrate an association of ADS use by family caregivers and higher DHEA-S levels on the next day. Prior research has found that higher DHEA-S levels are protective against the physiologic damaging effects of stressor exposure and may reduce risks of illness. Regular use of ADS may help reduce depletion of DHEA-S and allow the body to mount a protective and restorative response to the physiologic demands of caregiving. To our knowledge, this is the first study to examine DHEA-S levels across the day in connection with an intervention that affected daily exposure to stressors. (Am J Geriatr Psychiatry 2014; ■:■—■)*

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INTRODUCTION

Caregiving can be a highly stressful experience, particularly when assisting individuals with dementia (IWD). Daily and chronic caregiving stressors are associated with high levels of emotional distress, poor health outcomes, and increased mortality.^{1–3} Continual exposure to stressors exerts wear and tear on physiologic homeostatic systems (e.g., hypothalamic-pituitary-adrenal axis [HPA], cardiovascular, and immune systems), and these effects increase the risk of illness and mental health problems.^{4–6} Prior interventions have primarily targeted caregivers' skill in managing stressors but have not for the most part targeted the amount of exposure to stressors. By contrast, use of adult day service (ADS) programs (also known as adult day care) lowers caregivers' exposure to care-related stressors on days their IWD attends ADS and leads to decreased subjective stress and depressive symptoms.⁷ The current study extends these findings by examining the effects of ADS use at a physiologic level. Specifically, we focus on a marker of the caregiver's HPA axis, dehydroepiandrosterone-sulfate (DHEA-S). DHEA-S is an appropriate target for study, because it is responsive to the effects of daily and chronic stressors.^{8,9} By lowering daily stressor exposure, ADS use may provide caregivers with an opportunity to recover from the effects of stressors at a physiologic level as indicated by increased amounts of salivary DHEA-S.

DHEA-S has also been found to be associated with positive mood and depressive symptoms.^{10,11} Several studies have explored whether treatment with DHEA-S leads to reduced depressive symptoms, although results have been mixed.^{11,12} The present study approaches this question in a different way. Specifically, because daily stressors are associated with both lower DHEA-S and poorer daily mood, we explore if daily fluctuations in salivary DHEA-S that result from reducing daily stressor exposure with ADS use covary with daily positive mood and depressive symptoms.

Recent studies of daily stressors of caregivers offer insight into the association of daily events, mood, and physiologic markers of the stress response. Compared with numerous correlational reports, these studies use intensive repeated measures of

individuals to understand the causal, temporal sequence of daily events, mood, and the underlying physiologic mechanisms through which stressors may affect health and emotional well-being. Mausbach et al.¹³ found associations between caregivers' daily variability in pleasant activities and daily positive and negative mood, with stronger effects among individuals who reported higher initial burden. In a study of caregivers of persons with mild cognitive impairment, daily caregiving stressors were associated with elevated daily cortisol levels and flatter decline (i.e., less recovery at the end of the day).¹⁴ In a sample of long-term caregiving mothers of adolescents and adults with autism spectrum disorders, cortisol response was found to be low across the day, indicating burnout of the HPA axis stress response.¹⁵ These studies suggest that the day-to-day stressors of caregiving have effects on daily mood and may not provide an opportunity for physiologic recovery as indexed by salivary cortisol.

Much of the research on physiologic responses to daily stressors has focused on cortisol.¹⁶ Other markers of the HPA axis may also provide insight into how the body handles stress. DHEA and its sulfated form, DHEA-S, are anabolic steroids that protect the body from negative health consequences of stress exposure.^{10,17,18} Whereas cortisol is a catabolic hormone that supports the fight-or-flight stress response, DHEA-S contributes to recovery from stressors by mitigating the effects of inflammation and oxidative stress.¹⁹ Higher levels of DHEA-S may have possible neuroprotective effects in aging and Alzheimer disease.²⁰ In turn, low levels of DHEA-S among older people have been linked to cancer, insulin resistance, cardiovascular disease, and immune system deficiencies.^{9,21} Although acute stress typically leads to increases in DHEA-S, prolonged exposure to stressors attenuates DHEA-S levels, thereby reducing its health protective effects.^{8,20} DHEA-S levels also decrease with age.¹⁰ Thus, older people experiencing chronic high levels of stressor exposure may be particularly vulnerable to depletion of DHEA-S.

To date, most research on DHEA-S has been conducted in laboratory settings, and there are no published data on the daily effects of caregiving stressors on DHEA-S.²² There are also no field studies of DHEA-S where stressor exposure has been modified by an intervention during the observation period.

Given findings of DHEA-S attenuation with chronic stress, there may be a time-lagged energy shift in adrenal cortex release of DHEA-S. Further, the estimated half-life of DHEA-S is long, with estimates ranging from 13 to 28 hours,²³ which means it is cleared slowly from the blood. Thus, changes in salivary DHEA-S in response to a stress-reducing intervention such as ADS use may occur over a longer period of time than what would be expected of a biomarker such as cortisol, which responds quickly to stressor exposure.

The current study has two goals. First, we examine the effects of an intervention, ADS use, that lowers caregivers' daily exposure to care-related stressors on daily levels of salivary DHEA-S. Specifically, we compare caregivers' daily levels of DHEA-S on high stressor days where they spend most or all of their time with the IWD with low stressor days when their IWD attends ADS. Second, given prior findings of the association of DHEA-S and mood^{10,12} and to expand our understanding of DHEA-S in response to the intervention, we examine how daily DHEA-S levels influenced positive mood and depressive symptoms. We hypothesized that there will be significant differences in DHEA-S levels across days, with higher levels found on days after ADS use, and that daily DHEA-S will positively covary with daily positive mood and negatively covary with depressive symptoms.

METHODS

Design

We observed family caregivers of IWD who were enrolled in ADS programs across 8 consecutive days. The 8-day span allowed for collection of saliva and measures of mood on days when caregivers had primary responsibility for the IWD and days the IWD attended ADS. This classic within-person research design (A-B-A-B) allows us to determine efficacy by conducting within-person analyses that compare outcomes on days when participants do not receive treatment (A) with days they receive the intervention (B).²⁴ This approach provides an opportunity to observe causally the effects of introducing and withdrawing the intervention (ADS use) on physiologic and psychological recovery.

Participants

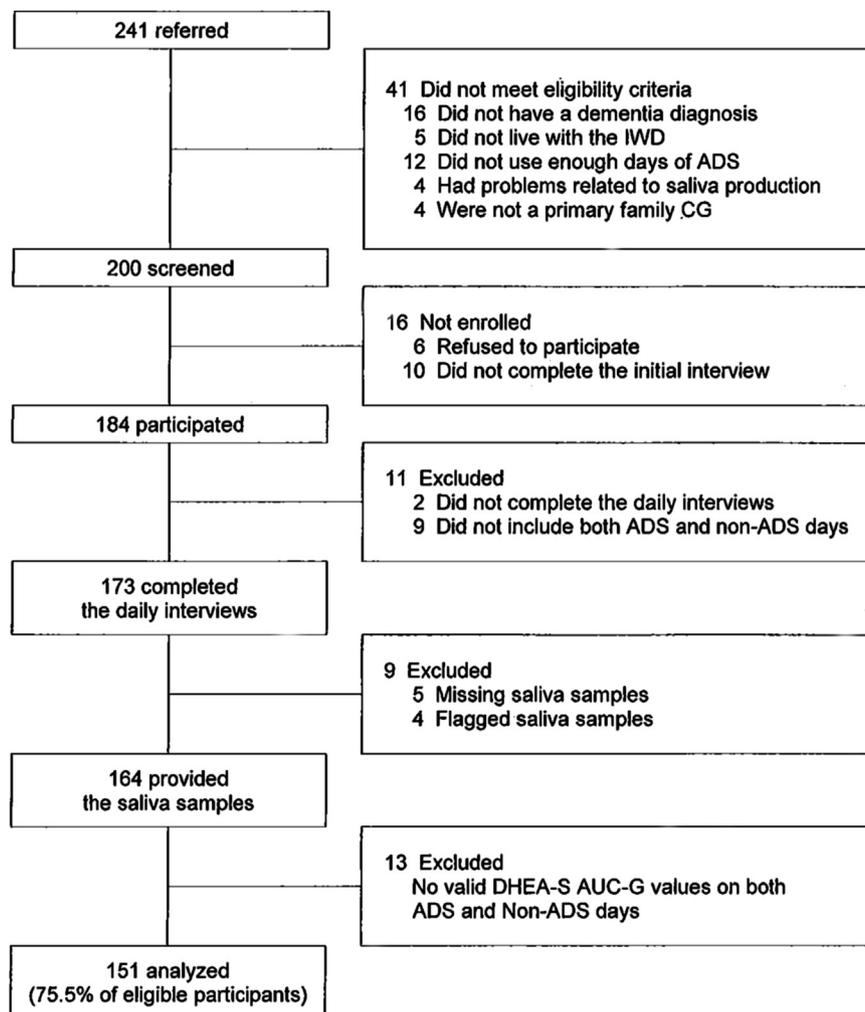
The sample consisted of caregivers assisting an IWD who attended an ADS program at least 2 days a week to ensure adequate treatment exposure. Caregivers had to be related to the IWD, live in the same household, and have primary responsibility for the IWD. We required that IWD and caregiver reside in the same household to ensure differences in stressor exposure between types of day, specifically, that caregivers would spend more of their time with the IWD on non-ADS days and have reduced time with the IWD on ADS days. The IWD had a physician's diagnosis of Alzheimer disease or another form of dementia. We did not include caregivers of people with mild cognitive impairment. Finally, caregivers were excluded if they had an endocrine disorder (e.g., Addison disease), which affects levels of DHEA-S, or if they were unable to produce saliva for any reason.

Recruitment was conducted at 57 ADS programs in northern and central New Jersey, the Philadelphia and Pittsburgh metropolitan areas, northern Virginia, and Denver, Colorado. We screened 241 caregivers in an initial telephone interview and found 41 (17%) who were not eligible for the study (Fig. 1). The most frequent reasons were as follows: the IWD did not have an eligible diagnosis of dementia (N = 16), the IWD did not live with the caregiver (N = 5), and the IWD did not use enough days of ADS (N = 12). Sixteen of the 200 eligible participants (8%) subsequently decided not to enroll in the study. Another 33 caregivers (16.5%) were eliminated from the analysis because of missing interview days or missing or flagged saliva samples (i.e., out of range values or times of collection). The resulting sample included 151 people (75.5% of eligible participants). Sample characteristics are shown in Table 1.

Procedures

An in-person interview was conducted to obtain signed consent and sociodemographic information. The interviewer also trained participants in the use of a home saliva kit. The kit contained 40 color-coded salivettes and a home collection diary. For the next 8 days, participants collected saliva five times a day (before getting out of bed, 30 minutes after getting out of bed, before lunch, before dinner, and before bed). Saliva collection times were recorded on

FIGURE 1. Flow diagram of participants. AUC-G: area under the curve with respect to ground; CG: caregiver; IWD: individual with dementia; ADS: adult day services.



salivettes and in the home collection diary. Participants kept salivettes in the refrigerator until shipment back to the lab. In the evenings of each of the 8 days, interviewers from the Penn State Survey Research Center obtained information about daily stressors and mood and confirmed saliva sample times. Participants received payments for completing the daily interviews.

Measures

Salivary DHEA-S. Once received at the Penn State Biomarker Core Lab, saliva samples were weighed and stored at -80°C . Salivary DHEA-S was

determined using commercially available enzyme immunoassay kits (DiaMetra, Milano, Italy). Samples were analyzed in duplicate, and tests that were greater than 10% difference in their coefficient of variance were rerun for accuracy. DHEA-S data were converted to nmol/mL (i.e., ng/mL \times 2.71).

DHEA-S area under the curve with respect to ground was calculated for each day to estimate total output on that day. Area under the curve with respect to ground uses a formula that adjusts for differences in the amount of time between samples.²⁵

Type of day. The IWD's use of ADS was confirmed during each daily interview (1 = ADS day, 0 = non-ADS day).

TABLE 1. Characteristics of Caregivers and IWD

	Mean	SD	Range
Caregiver characteristics			
Age, yr	62.08	10.62	39–89
Education ^a	4.39	1.22	1–6
Household income ^b	6.85	3.13	1–11
Female, N (%)	132	87.4	–
White, N (%)	108	71.5	–
Married, N (%)	107	70.9	–
Relation to IWD			
Spouse, N (%)	59	39.1	–
Child, N (%)	86	57.0	–
Employed, N (%)	63	41.7	–
Duration of care, mo	62.72	46.29	3–264
Frequency of ADS use	4.17	1.42	1–6
Medication use, N (%)	71	47.0	–
IWD characteristics			
Age, yr	81.85	8.61	57–100
Female, N (%)	89	58.9	–
ADL impairment ^c	3.07	0.48	2–4

Notes: Participant N = 151. SD: standard deviation; IWD: individual with dementia; ADS: adult day services; ADL: activity of daily living.

^aRated on a 6-point scale from 1 (less than high school) to 6 (post-college degree).

^bRated on a 11-point scale from 1 (less than \$10,000) to 11 (\$100,000 or over).

^cRated on a 4-point scale from 1 (does not need help) to 4 (cannot do without help).

Daily mood. Depressive symptoms were assessed with four items (feeling worthless, hopeless, ashamed, and so sad that nothing could cheer you up) from the Non-Specific Psychological Distress Scale.²⁶ Positive mood was measured with nine items from the Non-Specific Psychological Distress Scale and the Positive and Negative Affect Schedule.²⁷ Respondents were asked how frequently they felt each emotion over the past day along a 5-point scale from 1 (none of the day) to 5 (all day). Mean scores were calculated ($\alpha = 0.77$ for depressive symptoms; $\alpha = 0.92$ for positive mood).

Daily experiences. We included two measures of daily stressors, care-related stressors and non-care-related stressors, and a measure of positive daily experiences. These measures were used to confirm that ADS days reduced exposure to care-related stressors and as controls in exploring the association of DHEA-S and daily mood.

Care-related stressors were assessed by the Daily Record of Behavior, a 19-item measure of Behavioral and Psychological Symptoms of Dementia.²⁸ Caregivers reported the occurrence (1 = yes, 0 = no) of each behavior for three time periods in the previous

24 hours: waking to 9:00 a.m., 9:00 a.m. to 4:00 p.m., and 4:00 p.m. to bedtime. We summed the total number of behaviors reported each day.

Non-care-related stressors were assessed through the Daily Inventory of Stressful Events.²⁹ Caregivers reported the occurrence (1 = yes, 0 = no) of eight non-overlapping items during the previous 24 hours (e.g., stressors affecting friends or family, work-related events). Total number of daily events was reported.

Positive events were assessed with a scale from the Daily Inventory of Stressful Events. Caregivers reported the occurrence (1 = yes, 0 = no) of five non-overlapping items during the past 24 hours (e.g., share a laugh with someone, a positive experience at home). Total number of daily positive events was reported.

Covariates. Age and gender (1 = female, 0 = male), which could influence levels of DHEA-S, were included as between-person covariates. Specifically, DHEA-S levels decrease across the lifespan, and men display higher DHEA-S levels than do women.^{30,31} We assessed medications likely to affect DHEA-S (e.g., steroidal medications, antidepressants). We also considered two variables representing chronicity of care: duration of caregiving (months) and IWD's disability in 13 activities of daily living.³² Responses on activity of daily living items ranged from 1 (does not need help) to 4 (cannot do without help). Another covariate was total number of days the IWD used ADS during the 8 interview days. Finally, we considered caregiver's reported daily sleep quality as a within-person covariate of next day's DHEA-S and mood.

Statistical Strategy

To analyze daily data nested within persons, we used two-level multilevel models (SAS PROC MIXED).³³ We estimated the models via means of maximum likelihood and specified unstructured covariance matrices for the error structures of our data. We first examined the effects of ADS use on DHEA-S by modeling levels of DHEA-S for the d th day in the i th person at level 1 (within-person):

$$\text{DHEA-S}_{di} = \beta_{0i} + \beta_{1i}(\text{ADS today's use}_{di}) + \beta_{2i}(\text{ADS yesterday's use}_{di}) + \beta_{3i}(\text{Sleep quality}_{di} - \text{Mean Sleep quality}_i) + e_{di}$$

We included concurrent use of ADS (today's use, β_{1i}) in this model to examine differences in

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daily levels of DHEA-S by ADS use and then added yesterday's use of ADS (β_{2i}) to test for a lagged effect of ADS use. We also controlled for sleep quality at last night (β_{3i}), which was centered at individual means to represent the within-person effects.³⁴ At level 2 (between-person), we controlled covariates for the intercept: caregiver's age, gender, medication use, and duration of care, IWD's activity of daily living impairment, total ADS use during the 8 days, and individual mean levels of sleep quality. Except for a dummy-coded covariate (gender), all continuous covariates were entered into the model after being centered at the group mean.

We then conducted separate models to investigate the concurrent relationship of daily depressive symptoms and positive mood with daily DHEA-S levels. We parameterized mood for the d th day in the i th person at level 1 (within-person):

$$\begin{aligned} \text{Mood}_{di} = & \beta_{0i} + \beta_{1i}(\text{DHEA-S}_{di} - i\text{Mean DHEA-S}_i) \\ & + \beta_{2i}(\text{Care-related stressors}_{di} - i\text{Mean Care-related stressors}_i) \\ & + \beta_{3i}(\text{Non-care-related stressors}_{di} - i\text{Mean Non-care-related stressors}_i) \\ & + \beta_{4i}(\text{Positive event}_{di} - i\text{Mean Positive event}_i) \\ & + \beta_{5i}(\text{Sleep quality}_{di} - i\text{Mean Sleep quality}_i + e_{di}) \end{aligned}$$

where β_{1i} is the slope parameter for caregiver i 's change in the predicted mood for a one-unit change in levels of DHEA-S. We controlled for daily experiences (care-related stressors, non-care-related stressors, and positive events; β_{2i} , β_{3i} , and β_{4i}) and last night's sleep quality (β_{5i}) that could affect daily mood. The levels of DHEA-S, three daily experiences, and sleep quality included at level 1 were centered at individual means. At level 2, we controlled for the between-person covariates as well as individual mean levels of DHEA-S, three daily experiences, and sleep quality. For effect sizes of the multilevel models, we computed Cohen's d .³⁵

RESULTS

Participants completed an average of 6.7 days (standard deviation: 1.5) of saliva collection. ADS use averaged 4.17 days (standard deviation: 1.42) across the 8 days. Table 2 shows collection times and levels

of DHEA-S. As in prior work,²¹ DHEA-S demonstrated a decreasing diurnal rhythm.

As an initial step (Table 3), we confirmed that care-related stressors were significantly lower on days the IWD attended ADS, compared with non-ADS days. We then examined differences between ADS and non-ADS days in area under the curve with respect to ground of DHEA-S (Table 4). ADS use was significantly associated with increased DHEA-S levels on days after ADS use. Days after ADS use included both days the IWD attended and did not attend ADS. Effect size was small ($d = 0.11$).

Turning to the relationship between levels of DHEA-S and daily mood (Table 4), caregivers' positive moods showed a positive covariation with DHEA-S at the daily level, controlling for daily experiences. Effect size was medium ($d = 0.43$). Two examples (Fig. 2) illustrate this association. Daily depressive symptoms were not associated with daily DHEA-S.

Among covariates, longer duration of caregiving was associated with lower average levels of DHEA-S. Total ADS used during the 8 days was related to higher mean positive mood across the 8 days. Daily experiences were significantly associated with daily positive mood and depressive symptoms (within-person effects) and with average levels on these measures (between-person effects). Persons experiencing higher daily and average care-related and non-care-related stressors had higher depressive symptoms and lower positive mood, whereas positive events had the opposite associations with daily and average mood.

DISCUSSION

With growing numbers of IWD and family caregivers assisting them, it is increasingly important to identify interventions that mitigate the effects of chronic stress and reduce the risk of illness and mental health problems. This study uses promising approaches for the study of caregiver interventions,

TABLE 2. Summary of Daily Measures: Caregivers' Salivary DHEA-S, Daily Experiences, Sleep Quality, and Mood

	Mean	SD	ICC
Daily salivary DHEA-S			
Collection time (decimal hours)			
a. Waking	6.74	1.27	0.60
b. 30 min after waking	7.39	1.32	0.58
c. Before lunch	12.81	1.21	0.38
d. Around 5 p.m.	17.46	1.16	0.52
e. Before bed	22.61	1.13	0.67
Outcome level (nmol/L)			
a. Waking	15.65	11.29	0.79
b. 30 min after waking	10.33	5.34	0.74
c. Before lunch	8.28	4.68	0.56
d. Around 5 p.m.	8.25	4.17	0.66
e. Before bed	9.35	5.56	0.54
Total outcome: AUC-G	143.10	67.67	0.82
Daily experiences ^a			
Care-related stressors	5.42	5.53	0.76
Non-care-related stressors	1.09	1.23	0.37
Positive events	2.47	1.31	0.44
Daily sleep quality ^b			
Sleep quality	2.97	1.04	0.39
Daily mood ^c			
Depressive symptoms	1.14	0.41	0.59
Positive mood	3.06	0.93	0.73

Notes: Participant N = 151; Observation N = 1,011. SD: standard deviation; AUC-G: area under the curve with respect to ground; ICC: intraclass correlation.

^aCount of events or problems occurred during the 24-hour period.

^bRated on a 5-point scale from 1 (poor) to 5 (excellent).

^cRated on a 5-point scale from 1 (none of the day) to 5 (all day).

including the use of daily measurements and, particularly, demonstrating that an intervention that alters daily stressor exposure, ADS, has an effect on a physiologic measure of the stress response, DHEA-S. These findings are noteworthy because DHEA-S levels have been found to decrease with prolonged exposure to stressors.^{8,9} To our knowledge, this is the first study to examine DHEA-S levels across the day in connection with an intervention that affected daily exposure to stressors and to link DHEA-S levels to daily positive emotions. It is also one of the few studies demonstrating an effect of a caregiving intervention on physiologic indicators of stress.³⁶ Although effect size was small, these results suggest the value of broadening the focus of caregiver interventions to include their impact on relevant biologic risk factors associated with chronic stress and disease.

The increases in DHEA-S levels on days after ADS use may allow the body to mount a protective and restorative response to the physiologic demands of

caregiving. Although the mechanism is not fully understood, it has been suggested that the anabolic and antiglucocorticoid effects of DHEA-S may buffer the health-damaging effects of stress and cortisol.^{37,38}

The delayed increase in DHEA-S could be the product of a time-lagged energy shift in the adrenal cortex to release DHEA-S to compensate for stress-related cortisol dysregulation or the result of the long half-life of DHEA-S.²³ An important next step is to determine the long-term health benefits of these DHEA-S elevations as a result of the intervention.

DHEA-S is part of a larger system of responses to stressors. Many studies have presented cortisol-to-DHEA-S ratios as a way of capturing a broader view of the biologic process in stress responses.³⁹ We decided not to take this approach because of concerns about the limitations of ratios as a way of representing associations of dynamic processes. Ratios restrict statistical variance, and the same value may be produced by multiple combinations of the composite variables. A low cortisol-to-DHEA-S ratio could be the result of both values being high or both being low. Particularly, cortisol in chronic stress situations may be elevated or low,¹⁴ which renders a cortisol-to-DHEA-S ratio uninterpretable. Furthermore, although related, cortisol and DHEA-S appear to respond to events at different rates and to demonstrate different morning rhythms, which further limit the utility of a ratio.

Daily DHEA-S levels covaried significantly with positive mood, although it had no association with depressive symptoms. This finding confirms prior research that posited an association between DHEA-S and positive mood.¹⁰ In a secondary analysis, however, we did not find an association of daily ADS use and positive mood, although total ADS days used was significantly related to higher mean positive mood. Thus, although higher levels of DHEA-S were associated with increased positive mood, the influence of ADS on positive mood appears to be indirect. We also do not know the direction of the association of DHEA-S and positive mood. Prior work has viewed affect as both a precursor and consequence of HPA axis markers.¹⁶ As with DHEA-S, higher positive mood is a possible protective factor for caregivers, leading to improved ability to cope with stressors⁴⁰ and to better health and reduced mortality.⁴¹ Whether these effects are the result of or complementary to the associations with DHEA-S remains to be determined. We also note that other analyses from

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TABLE 3. Multilevel Model for Daily Experiences of Family Caregivers by ADS Use

	ADS Day		Non-ADS Day		ADS Effect ^a		
	Mean	SD	Mean	SD	B	(SE)	p
Care-related stressors	3.76	5.26	4.83	5.75	-1.18	(0.20)	<0.001
Non-care-related stressors	1.20	1.25	1.00	1.20	0.20	(0.07)	0.003
Positive events	2.61	1.30	2.39	1.31	0.17	(0.07)	0.012

Notes: Participant N = 151; Observation N = 1,011. SD: standard deviation; SE: standard error; ADS: adult day services; IWD: individual with dementia.

^aFixed effects of ADS use (1 = ADS day, 0 = non-ADS day) for differences between ADS day and non-ADS day in multilevel models; p values are based on t values of the ADS coefficients (df = 859); caregiver's age, gender, and employment, duration of care; IWD's activities of daily living impairment and number of ADS days were included as (between-person) control variables.

TABLE 4. Multilevel Models for Daily Levels of DHEA-S (AUC-G) and Mood

	DHEA-S (AUC-G)			Depressive Symptoms			Positive Mood		
	B	(SE)	p	B	(SE)	p	B	(SE)	p
Fixed effects									
Intercept	148.25	(15.05)	<0.001	1.05	(0.07)	<0.001	2.91	(0.15)	<0.001
Within-person predictors ^a									
ADS use (1 = yes)									
Today use	2.58	(1.91)	0.18	—	—	—	—	—	—
Yesterday use	3.80	(1.93)	0.049	—	—	—	—	—	—
DHEA-S (AUC-G)									
Daily experiences									
Care-related stressors	—	—	—	0.02	(0.00)	<0.001	-0.01	(0.01)	0.018
Non-care-related stressors	—	—	—	0.04	(0.01)	<0.001	-0.09	(0.02)	<0.001
Positive events	—	—	—	-0.02	(0.01)	0.005	0.18	(0.02)	<0.001
Sleep quality (last night)	1.81	(1.20)	0.13	-0.01	(0.01)	0.47	0.04	(0.02)	0.017
Between-person predictors ^b									
Frequency of ADS use	5.00	(3.70)	0.18	0.01	(0.02)	0.54	0.09	(0.04)	0.02
CG Female (1 = yes)	-6.65	(15.91)	0.68	0.08	(0.08)	0.30	0.22	(0.16)	0.17
CG Age, yr	-0.89	(0.50)	0.08	0.00	(0.00)	0.14	0.00	(0.01)	0.80
Medication use (1 = yes)	-5.32	(10.46)	0.61	0.04	(0.05)	0.41	-0.11	(0.10)	0.30
Duration of care, mo	-0.27	(0.11)	0.018	-0.00	(0.00)	0.35	0.00	(0.00)	0.15
IWD ADL impairment	18.75	(11.12)	0.09	-0.02	(0.05)	0.69	0.00	(0.11)	0.99
DHEA-S (AUC-G)	—	—	—	-0.00	(0.00)	0.53	0.00	(0.00)	0.36
Daily experiences									
Care-related stressors	—	—	—	0.02	(0.01)	0.003	-0.01	(0.01)	0.31
Non-care-related stressors	—	—	—	0.06	(0.03)	0.08	-0.09	(0.07)	0.23
Positive events	—	—	—	-0.09	(0.03)	0.001	0.43	(0.06)	<0.001
Sleep quality	1.36	(7.27)	0.85	-0.02	(0.04)	0.53	0.33	(0.08)	<0.001
Random effects									
Intercept VAR	3836.34	(459.22)	<0.001	0.08	(0.01)	<0.001	0.36	(0.04)	<0.001
Residual	703.74	(36.77)	<0.001	0.06	(0.00)	<0.001	0.19	(0.01)	<0.001
-2 Log likelihood	8,835.9			380.9			1,584.5		
AIC	8,861.9			418.9			1,622.5		

Notes: Participant N = 151; Observation N = 1,011. SE: standard error; CG: caregiver; IWD: individual with dementia; ADS: adult day services; ADL: activity of daily living; AUC-G: area under the curve with respect to ground; VAR: variance; AIC: Akaike's information criterion. For fixed effects, p values are based on t values of the coefficients. For random effects, p values are based on z values of the coefficients.

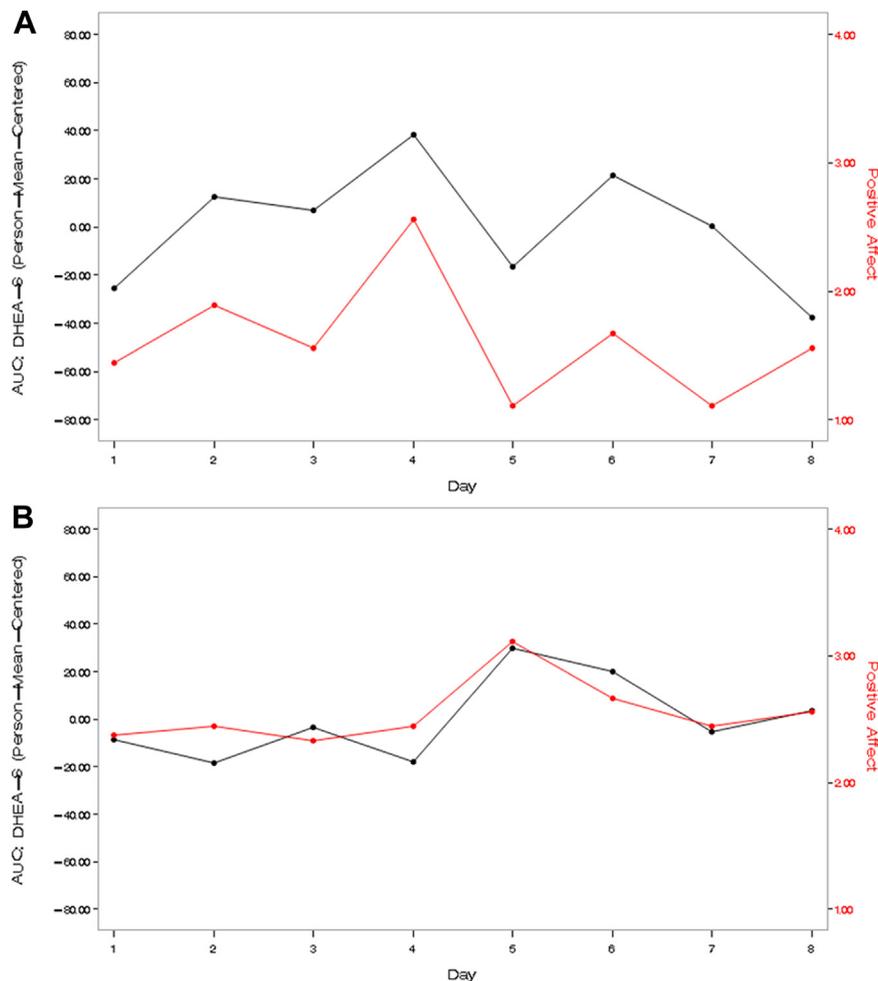
^aPerson-mean centered for continuous variables.

^bGroup-mean centered for continuous variables.

the current study identified that daily and cumulative ADS use had a broad impact on emotional well-being, including same day reductions of feelings of anger and buffering the effects of stressors on daily and average levels of depressive symptoms.⁷

This study has several limitations. First, the sample consisted of volunteers who were already using ADS. We cannot rule out that the sample might have selectively included people experiencing a positive response to ADS. Second, we did not use a typical control group

FIGURE 2. Two individual examples of the positive covariation between caregivers' self-reported positive moods and levels of salivary DHEA-S. AUC-G: area under the curve with respect to ground.



but rather used within-person comparisons of days when an intervention (ADS use) was delivered and not delivered. Although not widely used, this within-person design provides a different type of control than randomized trials by demonstrating covariation at the individual level between the introduction and withdrawal of an intervention and outcomes.²⁴ Third, ADS use had a smaller effect on care stressor exposure than in prior work,²⁸ although this may be due to using a count of problems rather than duration of episodes. Fourth, the short period of observation did not allow us to determine if improvements in DHEA-S levels with ADS use are cumulative over time or if benefits are found only in response to each specific usage. Fifth, we hypothesized that the next day effects on DHEA-S and positive mood are due to reduced exposure to care

stressors on the previous day, but we cannot rule other possible reasons for this delayed response. Finally, although gender was included as a covariate, a significant portion of our participants were women. Furthermore, the effects of DHEA-S levels differ by gender.^{30,31} DHEA-S plays a key role in testosterone production in males and estrogen production in females. In as much as estrogen is protective against the development of certain diseases (e.g., cardiovascular), DHEA-S changes in response to stress may alter disease risk for women who disproportionately outnumber men among caregivers.⁴²

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