Caregiver Psychological Distress: Longitudinal Relationships With Physical Activity and Diet

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Abstract
Given limited longitudinal research with caregivers (CGs, n = 122) of spouses with Alzheimer disease, and demographically matched noncaregivers (NCGs, n = 117), we compared these groups on psychological distress (anxiety, depression), burden, and health behaviors over 2 years. Analyses examined group differences in relationships of micronutrient recommended daily allowances (RDAs) and physical activity considering hours of care, psychological distress, and burden. Participants were measured and assessed on whether they met micronutrient intake and physical activity totaled over an average week. Regression analyses showed a total effect whereby NCGs had greater increases in meeting micronutrient allowances (RDAs) than CGs (b = 10.91, standard error [SE] = 4.74, 95% confidence interval [CI]: 1.56-20.26). Additionally, over time, NCGs had greater increases in physical activity, which was mediated by hours of care (b = 0.149, SE = 0.060, 95% CI: 0.034-0.270). These results suggest CGs may lack proper nutrients, and care hours may influence their health behaviors.

Keywords
caregivers, Alzheimer, psychological distress, health behaviors, longitudinal, physical activity

Introduction
The US population of adults aged 65 years and older is expected to reach 88 million by 2050.1 This demographic change would also see an increased incidence and prevalence of dementia.2 In fact, between 1990 and 2010, Alzheimer disease (AD) was the fastest growing burdensome disease in the United States, rising from the 25th to 12th most prevalent.2 Not surprisingly, 46% of all caregivers (CGs) in the United States care for someone with AD or other dementias.3 In 2016, CGs of persons with dementia provided 18.2 billion hours of unpaid assistance, or about $230.1 billion working hours.2 Given their importance to society, researchers have shown an interest in both CG demands and their responses to such demands.

One highly cited reference has described Alzheimer caregiving as a 36-hour day,4 a demanding situation that includes several hours per day caring for care recipients and engendering feelings of loss, suffering, prebereavement, lack of leisure time, fatigue, and health problems.5-11 Indeed, because of this unrelenting and demanding situation,4 caring for a loved one with AD has been labeled a prototypic chronic stressor.11 As examples, CG experiences are related to care-recipient impairment,13 CG perceived stress,14,15 isolation,14 and psychological distress (eg, depression, anxiety).8,13 Research has also focused on CG responses to specific experiences. For example, in contrast to psychological distress, which is a more distal response to life stressors, burden is measured in terms of more proximal CG demands.16,17 For example, recent work has observed relationships between burden and patient function/behaviors and found that such relationships were mediated by the hours spent caregiving.18 Hence, to better understand relationships between CG status (CGs and noncaregivers [NCGs]) with psychological distress, it is important to consider both the hours spent caregiving and burden.

Given the relevance of hours of care, burden, and psychological distress in the lives of CGs, most research has focused on these variables. However, ample data from other populations under stress suggest that health behaviors should also be...
studied. These include self-care and life-promoting behaviors, such as the preparation of well-balanced nutritious meals and physical activity.\textsuperscript{8,9,15} Health behaviors are important because they help maintain good health and, consequently, the continuation of caregiving. However, the hours spent caregiving may limit the time it takes to practice good health habits.

Indeed, positive health behaviors are neglected when time is limited\textsuperscript{7,19} and this is especially true in older adults. For example, older adults have poorer nutrition and eating habits than younger adults; about 60% of nursing home residents and about 90% in geriatric rehabilitation and hospital settings could be malnourished.\textsuperscript{20,21} Additionally, in contrast to macronutrient intake (proteins, fats, and carbohydrates), which are not definitive measures of good dietary health, micronutrient deficiencies may result in age-related cognitive deficits\textsuperscript{22,23} and may influence poor health behaviors in CGs. As examples, CGs may be at higher risk for malnutrition than NCGs\textsuperscript{24} and they may also be more likely to consume fast food and soda compared to NCGs.\textsuperscript{25} Malnutrition may also be more prevalent in CGs with depressed mood.\textsuperscript{24,26}

Just as caregiving tasks and burden may negatively influence their diet, moderate-to-high involvement in caregiving tasks may impact their ability to maintain adequate exercise relative to NCGs.\textsuperscript{27-29} This may, however, be specific to certain types of CGs. For example, although CGs of people with osteoporotic fractures did not have restricted exercise relative to NCGs,\textsuperscript{30} CGs of family members with ovarian cancer did exhibit decreased physical activity after their family member’s diagnosis.\textsuperscript{31} Burden is also predictive of negative health behaviors (eg, alcohol consumption, sedentary activity, smoking) in CGs.\textsuperscript{19} Likewise, physical activity has been associated with lower levels of CG distress and burden,\textsuperscript{32} and CG distress may mediate relationships between CG demands and health outcomes.\textsuperscript{10} It is, therefore, unclear which factors (eg, hours caregiving, CG burden/distress, the definition of exercise/physical activity) are most relevant to the diverse findings across CG studies.

Given relatively limited longitudinal research on health behaviors in both CGs and NCGs and the absence of research documenting relationships of specific health behaviors (eg, micronutrient intake) with psychological distress and burden, we examined relationships of CG status with psychological distress and health behaviors (recommended micronutrient intake and physical activity) over 2 years. Three complex hypotheses were proposed and examined with 6 serial mediation regression models. For hypothesis I, it was expected that CGs would have poorer micronutrient intake than NCGs and that average hours of care, psychological distress, and/or burden would mediate this relationship over time. For hypothesis II, it was expected that CG status would predict lower levels of physical activity and that, over time, greater average hours of care, psychological distress, and/or burden would mediate this relationship. For hypothesis III, it was expected that CGs would have greater burden and distress and these would lead to decrements in micronutrient intake and less physical activity. Overall, research has examined relationships of CG status with psychological distress and, to some extent, relationships between health behaviors and psychological distress.\textsuperscript{8,15,24,33}

However, to our knowledge, no longitudinal studies have examined micronutrient intake in CGs or mediation pathways of CG micronutrient intake by hours of care, psychological distress, and burden.

**Method**

**Design and Participants**

Spouse CGs (n = 122) of persons with AD were compared to 117 spouse NCGs who were demographically group-matched on age, gender, race, income, and education. Caregivers were recruited from mailings to physicians, a university AD registry, the Alzheimer’s Disease Association, and printed or electronic media. Caregivers had to be 55 years and older, function independently, and be the primary CG for their spouse care recipient. The diagnosis was done for AD care recipients, but not for CGs, NCGs, or spouses of NCGs. Although the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition criteria were used, these care recipients would probably have received the same diagnosis using the DSM-IV because (1) they were done by diagnosticians, (2) care recipients’ mean Mini-Mental Status Examination (MMSE) score at entry was 17 and consistent with late-mild or early moderate stage dementia, and (3) care recipients declined to a mean score of 13.5 over 2 years, a result consistent with the expected AD trajectory.\textsuperscript{34} Also, the hours of care reported by their CG spouses (eg, 7.90 h/d at baseline) was consistent with individuals at this level of dementia.\textsuperscript{35} The NCGs for this study were recruited from retirement organizations, senior centers, and the media. They had to be aged 55 years, able to care for themselves, and could not be caring for a family member/friend.

This protocol was also approved by the institutional review board of the University of Washington (protocol #11161). Written informed consent was obtained from all participants. At the end of the study, participants were given $75 for completing it. Table 1 presents demographic data that suggest matching was effective, along with baseline and outcome data for the groups. Table 2 contains demographic data for care recipients.

**Measures**

**Caregiver status.** At time 1 (T1), CGs had been caring for their spouse for a mean of 44 months (standard deviation = 16.9). Caregiver status was dummy coded with CGs as the baseline group.

**Hours of care.** To estimate objective stress load on CGs,\textsuperscript{36} and to assess acute/intermittent caregiving in NCGs, we examined the hours of care per day both groups performed for activities of daily living.

**Psychological distress.** This was assessed using 3 measures: (1) 13-item Beck Depression Inventory (BDI) to assess severity of
depressed mood; (2) Hamilton Rating Scale of Depression (HRSD) to examine depressive symptoms present for at least 2 days prior to assessment; and (3) State scale of the State-Trait Anxiety Inventory (STAI). The HRSD was assessed by an interviewer (master’s level student in clinical psychology) who was trained by a psychiatrist. Both STAI and BDI were self-rated. These measures were completed in our offices, but some CGs and NCGs could not come to the office for their third assessment and were tested in their homes (see Table 1). Internal consistencies across the time points varied from 0.86 to 0.87 (BDI), 0.77 to 0.80 (STAI), and 0.76 to 0.79 (HRSD).

To provide a parsimonious measure of psychological distress, these measures were combined using principal component analyses. This was possible because they were theoretically related, and at each time their interrelationships yielded one principal component that explained 70% of the variance. Given similar structures at all times, psychological distress T1 was used as a covariate, and psychological distress at time 2 (T2) was used as a mediator in subsequent analyses.

Micronutrient intake. At T1 and time 3 (T3), Three-day Food Diaries from the University of Minnesota were used to assess micronutrients. The diaries included approximately 800 food items and 450 recipes. Participants recorded their diet for 3 consecutive days: Friday, Saturday, and Sunday from the past week. In these analyses, we used micronutrient intake, in lieu of macronutrients, because their beneficial intake is less ambiguous. For example, although some macronutrients (e.g., carbs

Table 1. Baseline and Outcome Comparisons for CGs and NCGs.

|                      | CGs, n = 122 | NCGs, n = 117 |
|----------------------|-------------|--------------|
| **Baseline measures**|             |              |
| Gender               | 61.48       | 64.10        |
| Race                 | 94.26       | 92.31        |
| Psychotropic drugs   | 31.15       | 15.38        |
| Nursing home status  | 16.39       | 7.70         |
|                      | % Frequency | % Frequency  |
| **Outcome measures** |             |              |
| Total RDA counts met | 7.09        | 7.62         |
| Physical activity    | 81.80       | 82.47        |

Abbreviations: CG, caregiver; M, mean; NCG, noncaregiver; RDA, recommended daily allowance; SD, standard deviation; T1, time 1; T2, time 2; T3, time 3.

*Percentage of women.

bPercentage of white.

cPercentage taking medication.

dPercent in nursing home.

*p < .001 between CGs and NCGs from t test comparisons.

Note: The T3 RDA counts are for 118 Caregivers and 112 Noncaregivers.

Table 2. Baseline Measures for Care Recipients and Spouses of Noncaregivers.

|                      | AD Care Recipients, n = 122 | Spouses of Noncaregivers, n = 117 |
|----------------------|----------------------------|-----------------------------------|
| **Baseline Measures**| M SD                       | M SD                              |
| Age (years)          | 74.81 8.56                 | 71.12 7.17                        |
| Education (years)    | 14.66 3.10                 | 14.86 3.28                        |

Abbreviations: AD, Alzheimer disease; M, mean; SD, standard deviation.
from white bread). The micronutrients were 9 vitamins from fruit) are nutritionally dense, others are less dense (carbs and folate); and 4 minerals: calcium, iron, zinc, and magnesium. Other micronutrients were not analyzed because of limited data. These raw data were translated to recommended daily allowances (RDAs) to assess eating habits compared to standards. Recommended daily allowances were obtained from Dietary Reference Intakes developed by the Food and Nutrition Board at the Institute of Medicine. We used the most recent nutritional gender-normed guidelines for gender and this age range. Participants were classified as having met or not having met the RDA. Values below the RDA cut off were scored “0” and those greater than or equal to the cutoff were scored “1.” A RDA sum of all micronutrients was calculated for T1 and T3. Total RDA count (recommended micronutrient intake) T1 was used as a covariate and total RDA count T3 was used as an outcome in the models (Table 1).

Physical activity. Assessed at T1, T2, and T3 in which 12 metrics were presented in a 2-way grid (4 rows by 3 columns). The rows corresponded to activity levels: (1) sedentary (eg, sitting, reading), (2) light (eg, craftwork, standing up), (3) moderate (eg, walking at normal pace, light yard work/recreation), and (4) vigorous activity (mopping, heavy yard work, biking, etc). The 3 columns corresponded to time: (1) number of days/week, (2) average hours/day, and (3) level of effort. Effort included a grid from 0 to 4, where “0” was “minimal effort” (no sweat, no increase in heart rate) and “4” was “maximal effort” (profuse sweating, heavy breathing, and increased heart rate). The grid used was similar to standardized measures such as the Community Healthy Activities Model Program for Seniors (CHAMPS). For analyses, all physical activity levels were used, except sedentary. Scores were obtained by taking the product of number of days per week, average hours per day, and level of effort of each activity (light, moderate, and vigorous). A total for each time point was then obtained from the sum of light, moderate, and vigorous activity for each participant. As with RDA count, total physical activity T1 was used as a covariate and total physical activity T3 was used as an outcome (Table 1).

Help in the home. Help was used as a covariate in the analyses. It included help from family/friends such as transportation, meals, chores, heavy cleaning, legal/money matters, and spouse care. Responses were coded from 1 (have not received help) to 7 (have received help).

Psychotropic medication. Coded as yes or no and was a covariate because of its importance to mental/physical health and possible influence on caregiving. Both CGs and NCGs differed significantly on use, \( \chi^2 (1, N = 238) = 8.49, P = .004 \) (Table 1).

Self-rated health. Health was self-rated from 1 (poor) to 5 (very good) and used as a covariate in analyses.

Mini-Mental Status Examination. To measure cognitive functioning and loss, MMSE was collected for spouses of CGs (AD care recipients) and for spouses of NCGs. Both AD care recipients and the spouses of the NCGs were assessed in university offices by an MS clinical psychologist. However, at T3, some patients with AD and spouses of NCGs were in long-term care facilities (Table 1). Their corresponding CGs and NCGs were tested in our offices or in their homes.

Screen for caregiver burden. The screen for caregiver burden was used to assess the appraisal of distress in response to 25 CG activities/experiences. It has demonstrated content, criterion, and internal reliability.

Results

Data Screening and Analyses

We phone-screened 231 CG–patient with AD couples. Of these, 155 received detailed phone interviews because the patient with AD and spouse (1) could come to our study clinics/offices and were (2) living within a 50-mile radius. The latter was done for convenience because our previous studies had to assess couples in their homes and/or persons with AD had to be assessed in institutions near their homes. Of the 155 couples, 25 failed to register for phone interviews. Thus, 130 spouse CGs and their spouses (AD care recipients) and 125 NCG spouses (and their AD-free spouses) met study criteria and were enrolled for office interviews. Over 2 years, 3 CGs and 1 NCG died, 4 CGs and 4 NCGs moved, 1 CG and 1 NCG reported being too ill, and 2 NCGs refused to continue. This left 122 CGs and 117 NCGs. Our good 2-year retention rate resulted from our detailed contacts with next of kin/friends, repeated phone calls, and greeting cards between time points. We examined CGs and NCGs at study entry (T1), 1 year after T1 (T2), and 2 years after T1 (T3). Face-to-face office interviews occurred at T1 and T2. At T3, 87% of the interviews were in office and 13% in participants’ homes. Missing data in self-report measures were checked and corrected during interviews.

Descriptive analyses showed that despite not having a spouse with AD, at different intervals, some NCGs reported spending time caring for their spouses. However, when this occurred (n = 23 at T1, n = 27 at T2, and n = 33 at T3), the number was minimal. Non-CGs had a mean number of hours of only 0.75 hours at T1, 1.21 hours at T2, and 1.27 at T3. In contrast, at all times, CGs spent many more hours per day caregiving (Table 1). Importantly, the means for hours of care per day were similar to those of a national survey (7.90 hours). Also, the relationship between hours of care and MMSE was high for the combined groups, \( r(237) = -0.57, P < .001 \), moderate in CGs, \( r(120) = -0.33, P < .001 \), and unrelated in NCGs, \( r(115) = -0.02, P = .82 \). For this reason, we expected that among CGs, lower MMSE scores would require more hours of care and be related to greater burden. Indeed, hours of care has been shown to mediate relationships of care-recipient problems and CG.
Four additional models (Figures 1–4) assessed burden’s relationship with physical activity and RDA count over time. Thus, 6 mediation models were examined. To increase power, the models included as few variables as possible to allow more degrees of freedom for the error term. Data were also screened for outliers and examined using PROCESS in SPSS version 23 (IBM Corp, Armonk, New York). The outcome variables (Table 1) were log transformed to be more normally distributed and continuous variables centered. Prior to these analyses, homogeneity of variance was verified by examining plots of residuals with the predicted values. Variance inflation and tolerance values among the models’ variables showed little evidence of high multicollinearity. Importantly, models were proposed a priori based on relationships we hypothesized between the predictors, mediators, and outcomes and previous literature.

Hypothesis I

In support of hypothesis I, correlations were observed for CG status with average hours of care T1, $r(220) = 0.55$, $P < .001$; psychological distress T2, $r(220) = 0.77$, $P < .001$; and RDA total T3, $r(220) = 0.60$, $P < .001$, after controlling for covariates, psychological distress T1, and RDA total T1. The overall model was significant, $R^2 = 0.36$, $F(9, 220) = 13.62$, $P < .001$. A total effect (pathway c, Figure 5) was observed such that more NCGs met RDA requirements than did CGs, $b = 10.91$, standard error (SE) = 4.74, $t(222) = 2.30$ ($P = .02$, 95% confidence interval [CI]: 1.56-20.26) and a marginal burden. Four additional models (Figures 1–4) assessed burden’s relationship with physical activity and RDA count over time. Thus, 6 mediation models were examined. To increase power, the models included as few variables as possible to allow more degrees of freedom for the error term. Data were also screened for outliers and examined using PROCESS in SPSS version 23 (IBM Corp, Armonk, New York). The outcome variables (Table 1) were log transformed to be more normally distributed and continuous variables centered. Prior to these analyses, homogeneity of variance was verified by examining plots of residuals with the predicted values. Variance inflation and tolerance values among the models’ variables showed little evidence of high multicollinearity. Importantly, models were proposed a priori based on relationships we hypothesized between the predictors, mediators, and outcomes and previous literature.

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Figure 3. Regression model for nutrient intake without hours of care. Pathways are displayed as standardized $\beta$ coefficients in which asterisks denote significant pathway relationships for CG status while considering the variable in between (pathways $b_1$, $b_2$, and $d$). Covariates included gender, help in the home, self-rated health, psychotropic medications, psychological distress at T1, age, and living situation (assisted living or own home) and recommended micronutrient intake (total RDA count) at T1. CG indicates caregiver; RDA, recommended daily allowance; T1, time 1; T2, time 2; T3, time 3.

Figure 4. Regression model for physical activity without hours of care. Pathways are displayed as standardized $\beta$ coefficients in which asterisks denote significant pathway relationships for CG status while considering the variable in between (pathways $b_1$, $b_2$, and $d$). Covariates included gender, help in the home, self-rated health, psychotropic medications, psychological distress at T1, age, and living situation (assisted living or own home) and physical activity at T1. CG indicates caregiver; T1, time 1; T2, time 2; T3, time 3.

Figure 5. Regression model for nutrient intake. Pathways are displayed as standardized $\beta$ coefficients in which asterisks denote significant pathway relationships for CG status while considering the variable in between (pathways $b_1$, $b_2$, and $d$). Covariates included gender, help in the home, self-rated health, psychotropic medications, psychological distress at T1, age, and living situation (assisted living or own home) and recommended micronutrient intake (total RDA count) at T1. CG indicates caregiver; RDA, recommended daily allowance; T1, time 1; T2, time 2; T3, time 3.
direct effect of CG status (pathway c', Figure 5) onto RDA requirements was observed, \( b = 10.02, SE = 5.15, t(229) = 1.95 (P = .05, 95\% CI: -0.133 to 20.18) \). Hence, in the unmediated model, NCGs had greater increases in fulfilling recommended micronutrient requirements. No other significant indirect effects were observed. Further, when psychological distress T2 was replaced with burden T2 as a mediator between hours of care and total RDA count T3, the total effect was maintained, but there were no indirect effects or a direct effect (Figure 1). Overall, this hypothesis was partially supported.

**Hypothesis II**

For hypothesis II, significant relationships were observed for CG status with average hours of care T1, \( r(229) = 0.56, P < .001 \); psychological distress T2, \( r(229) = 0.78, P < .001 \); and physical activity T3, \( r(229) = 0.53, P < .001 \), after controlling for covariates, psychological distress T1, and physical activity T1. For physical activity, analyses were done initially using light, moderate, and vigorous activity separately and moderate and vigorous activity combined in one measure; however, there were no significant results. A more complete picture and more robust findings were found by combining light, moderate, and vigorous physical activity. In this analysis, the overall model was significant, \( F(9, 229) = 8.91, P < .001, R^2 = 26 \). Here, a mediation analysis did not show a significant total effect (pathway c, Figure 6) or a direct effect (pathway c', Figure 6). After taking 5000 bootstrapped samples, there was a significant total indirect effect, partially standardized \( b = 0.152, SE = 0.062 (95\% CI: 0.034-0.278) \), suggesting that fewer hours of care and less distress in NCGs may have positively influenced physical activity. There was also an indirect effect 1, such that hours of care T1 mediated the effect of CG status on physical activity T3, partially standardized \( b = 0.149, SE = 0.060 (95\% CI: 0.034-0.270) \). There were no other significant indirect effects. Further, when burden T2 was included as a mediator between hours of care T1 and physical activity T3, only the indirect effect 1 was maintained (Figure 2). There was no total indirect effect. Overall, this hypothesis was partially supported.

**Hypothesis III**

Hypothesis III examined relationships of CG status with burden T1, psychological distress T2, and total RDA count or physical activity T3. For the analysis with RDA counts (Figure 3), only a total effect was observed for CG status with total RDA count T3, \( b = 10.91, SE = 4.74, t(220) = 2.30 (P = .02, 95\% CI: 1.56-20.26) \). For the latter analysis with physical activity (Figure 4), only a total indirect effect was observed, partially standardized \( b = 0.406, SE = 0.200 (95\% CI: 0.009-0.800) \), so this hypothesis was partially supported.

**Discussion**

The primary goals of this study were to examine interrelationships of CG status with psychological distress, burden, and health behaviors (recommended micronutrient intake and physical activity) over 2 years (T1, T2, and T3). Hypothesis I stated that over time (T1-T3), CGs would meet less micronutrient RDAs than NCGs and that hours of care T1 and psychological distress or burden at T2 would mediate this relationship. This hypothesis was partially supported using a serial mediation model. Caregiver status predicted less recommended micronutrient intake T3 after controlling for total RDA count T1, help in the home, self-rated health, gender, age, psychotropic medication, T3 living situation (home vs institution), psychological distress T1, hours of care T1, and psychological distress T2. However, these relationships were not mediated by hours of care T1 or psychological distress T2. Furthermore, when burden T2 was examined in place of psychological distress, a total effect was still observed.

Previous research has discussed nutrient deficiencies in CGs.24,26,33 This study extends this research using detailed diaries to document that CGs (and even NCGs) did not meet dietary standards at 2 times over 2 years. Such deficiencies are
relatively common in older adults, but they may be more compromised in older CGs. In fact, CGs are known to consume less nutrient-dense food, which is problematic because micronutrients are important for preventing chronic disease. Importantly, they foster CG functioning and health, which may help CGs provide better care. Using a sample of moderate to higher income CGs, these results highlight the need for nutrient-dense foods for proper body functioning. However, they also suggest that lower income CGs might be at even higher risk for inadequate nutrition because they would be expected to have poorer diets than CGs with higher incomes. Programs that foster better nutrition intake in low-income CGs are warranted.

Similar to hypothesis I, hypothesis II stated CGs would report less physical activity at T3 than NCGs and this relationship would be mediated by hours of care T1 and psychological distress or burden at T2. We observed a total indirect effect and an indirect effect of hours of care as a mediator of the relationship of CG status with physical activity at T3 after controlling for physical activity at T1, help in the home, self-rated health, gender, age, T3 living situation, psychotropic medication, and psychological distress at T1 and T2. However, there was no indirect effect of both these mediators or of psychological distress alone. When burden was included in place of psychological distress T2, only the indirect effect of hours of care to physical activity was maintained. Hence, this research hypothesis was partially supported.

The middle-to-higher incomes of CGs and NCGs may help explain their similar levels of physical activity at T3, Higher incomes are associated with less distress, better health, and/or more time for recreation. Studies conducted with lower incomes and poorer health might observe stronger relationships between distress and health habits. Physical activity may also overlap with hours of care as the results showed CGs who provided more care were more active. Indeed, caregiving requires physical exertion, such as walking from room to room. Clearly, associations among hours of care, physical activity, and psychological distress in AD CGs need to be further disentangled to better understand whether physical activity helps to reduce potential psychological distress.

Contrary to our hypotheses, the mediation models of burden with hours of care, distress, and health habits showed that burden and psychological distress were not additional mediators and did not show relationships beyond what was observed in tests of hypotheses I and II. As such, burden and distress did not have major influences on these CG behaviors over time. Rather, neglect may help explain the observation of poor health behaviors in CGs and this may partially explain CG reports of poorer health and greater physiological dysregulation than NCGs. For example, burden was highly related to CG status in this study, which may have contributed to the lack of differences observed between hypotheses I, II, and III. Importantly, Lin and colleagues have demonstrated that hours of care were critical in explaining relationships of patient behaviors/function with burden. Other research over the course of 1 year has linked reductions in CG health behaviors with depression. Also, psychological distress may increase in CGs of patients with cancer, with care intensity potentially altering health behaviors such as reduced physical activity. These relationships were not observed here possibly because of the 2-year time interval and/or because the analyses controlled for distress. Also, in the current study, CGs may have adjusted to their roles before recruitment (they were caring, on average, for 44 months), and there may not have been substantial changes in care recipients over the next 24 months.

**Limitations and Advances**

As in many clinical studies, we did not sample CGs and NCGs from the same population. As such, there may be unmeasured variables that influenced group differences independent of caregiving. However, we attempted to control for such differences by matching groups on age, gender, income, race, and education, variables relevant to psychological distress, health behaviors, and health. We assessed hours of care, help, and physical activity using self-reports. Although this is common in CG studies, relationships between hours of care and distress may have been influenced by fatigue, subjective biases, and cognitive dissonance. Variability in reported hours may also have overlapped with physical activity reports, thereby obscuring relationships of CG status with physical activity. Descriptive information for micronutrient intake showed both CGs and NCGs lacked certain nutrients, but did not specify which requirements. Devices that measure commonly consumed micronutrients (eg, potassium) and that track physical activity more objectively would be valuable additions to this research. Finally, the higher incomes in these samples are not indicative of all AD CGs or NCGs. Lower income CGs might be more nutritionally deprived and less physically healthy.

Despite these limitations, this study had some advantages. These include (1) matching CGs and NCGs on 5 demographic variables and the use of (2) 3 time points over 2 years, (3) distress measures with good psychometric properties, (4) reputable diet measures, and (5) controls of multiple variables. Finally, our findings may be conservative because these groups were in good health, and the range of poor health behaviors may have been restricted. In sum, relationships of CG status, psychological distress, burden, and health behaviors have been examined previously, but few studies have been longitudinal with multiple indicators to predict health behaviors in CGs and NCGs.

**Conclusion**

These results may be relevant to organizations that foster positive health behaviors in CGs and their care recipients. These include eating nutritious foods and obtaining adequate exercise. Our findings suggest that hours of care may help explain psychosocial and behavioral differences in CGs and NCGs more than the dichotomous classification based on “married to and living with someone with AD.” It is also unclear how many reports of hours of care overlap with reports of physical activity. For example, when light activity was added to the measurement of physical activity, mediation was observed, but
when this measure only included moderate-vigorous levels, mediation was not observed. Hence, hours of care may overlap with light activity. Better delineation is needed in the measurement of hours of care versus light activity for understanding these relationships. In sum, this study should add to the importance of hours of care and psychological distress as they relate to health behaviors in CGs. This is particularly noteworthy for micronutrient intake and supports current health policy to increase nutrition assistance (access to an adequate diet and assistance with diet recommendations) in older populations.53

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References
1. He W, Goodkind D, Kowal P. U.S. Census Bureau, International Population Reports, P95/16-1, An AgingWorld: 2015. U.S. Washington, DC: Government Publishing Office; 2016. http://www.census.gov/content/dam/Census/library/publications/2016/demo/p95-16-1.pdf. Accessed November 24, 2016.
2. Alzheimer’s Association. 2017 Alzheimer’s disease facts and figures. Alzheimer’s Dementia. 2017;5(3):234-270. doi:10.1016/j.jalz.2009.03.001
3. Wolf JL, Spillman BC, Freedman VA, Kasper JD. A national profile of family and unpaid caregivers who assist older adults with health care activities. JAMA Intern Med. 2016;176(3):372-379. doi:10.1001/jamainternmed.2015.7664
4. Mace NL, Rabins PV. The 36-Hour Day: A Family Guide to Caring for People Who Have Alzheimer Disease, Related Dementias, and Memory Loss. 5th ed. Baltimore, MA: JHU Press; 2011.
5. Baille V, Norbeck JS, Barnes LEA. Stress, social support, and psychological distress of family caregivers of the elderly: correlates of feelings of burden. Gerontology. 1980;20(6):649-655. doi:10.1037/0033-2909.129.6.946
6. Vitaliano PP, Russo J, Young HM, Teri L, Maiuro RD. Predictors of burden in caregivers of individuals with Alzheimer’s disease. Psychol Aging. 1991;6(3):392-402. doi:10.1037/0882-7974.6.3.392
7. Zarit SH, Reever KE, Bach-Peterson J. Relatives of the impaired elderly: correlates of feelings of burden. Gerontologist. 1980;20(6):649-655. doi:10.1037/0033-2909.129.6.946
8. Mace NL, Rabins PV. The 36-Hour Day: A Family Guide to Caring for People Who Have Alzheimer Disease, Related Dementias, and Memory Loss. 5th ed. Baltimore, MA: JHU Press; 2011.
9. Kaiser MJ, Bauer JM, Rámsch C, et al. Frequency of malnutrition in older adults: a multinational perspective using the Mini Nutritional Assessment. J Am Geriatr Soc. 2010;58(9):1734-1738. doi:10.1111/j.1532-5415.2010.03016.x
10. Vellas B, Guigoz Y, Garry PJ, et al. The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. Nutrition. 1999;15(2):116-122. doi:10.1016/S0899-9007(98)00171-3
11. Black MM. Micronutrient deficiencies and cognitive functioning. J Nutr. 2003;133(11):3927S-3931S. doi:10.1093/jn/133.11.3927 S
12. Black R. Micronutrient deficiency: an underlying cause of morbidity and mortality. 2003;79-79. https://www.scielo.org/scielo.php?pid=S0042-96862003000200002&script=sci_arttext
13. Brunser K, Kugler JE, Devanand DP, Scarmeas N, Zhu C, Stern Y. The differential impact of unique behavioral and psychological symptoms for the dementia caregiver: how and why do patients’ individual symptom clusters impact caregiver depressive symptoms? Am J Geriatr Psychiatry. 2013;21(12):1277-1286. doi:10.1016/j.jagp.2013.01.062
14. Schulz R, Sherwood PR. Physical and mental health effects of family caregiving. J Soc Work Educ. 2008;44(3):doi:10.5175/JSWE.2008.773247702
15. Vitaliano PP, Zhang J, Savage MV, Hirsch IB, Siegler IC. A path model of chronic stress, the metabolic syndrome, and coronary heart disease. Psychosom Med. 2002;64(3):418-435. PMID:12021416
16. Vitaliano PP, Zhang J, Scanlan JM. Is caregiving hazardous to one’s physical health? A meta-analysis. Psychol Bull. 129(6):946-972. doi:10.1037/0033-2909.129.6.946
17. Grad J, Sainsbury P. Mental illness and the family. Lancet. 1963;281(7280):544-547. doi:10.1016/S0140-6736(63)91339-4
18. Dumont S, Turgeon J, Allard P, Gagnon P, Charbonneau C, Vézina L. Caring for a loved one with advanced cancer: determinants of psychological distress in family caregivers. J Palliat Med. 2006;9(4):912-921. doi:10.1089/jpm.2006.9.912
19. Ormstein K, Gaugler JE, Devanand DP, Scarmeas N, Zhu C, Stern Y. The differential impact of unique behavioral and psychological symptoms for the dementia caregiver: how and why do patients’ individual symptom clusters impact caregiver depressive symptoms? Am J Geriatr Psychiatry. 2013;21(12):1277-1286. doi:10.1016/j.jagp.2013.01.062
20. Son J, Erno A, Shea DG, Femia EE, Zarit SH, Stephens MAP. The caregiver stress process and health outcomes. J Aging Health. 2007;19(6):871-887. doi:10.1177/0898264307308568
21. Vitaliano PP, Russo J, Young HM, Teri L, Maiuro RD. Predictors of burden in caregivers of individuals with Alzheimer’s disease. Psychol Aging. 1991;6(3):392-402. doi:10.1037/0882-7974.6.3.392
22. Black MM. Micronutrient deficiencies and cognitive functioning. J Nutr. 2003;133(11):3927S-3931S. doi:10.1093/jn/133.11.3927 S
23. Black R. Micronutrient deficiency: an underlying cause of morbidity and mortality. 2003;79-79. https://www.scielo.org/scielo.php?pid=S0042-96862003000200002&script=sci_arttext
24. Rullier L, Lagarde A, Bouisson J, Bergua V, Torres M, Barberge-Gateau P. Psychosocial correlates of nutritional status of family
22. Hoffman GJ, Lee J, Mendez-Luck CA. Health behaviors among baby boomer informal caregivers. Gerontologist. 2012;52(2): 219-230. doi:10.1093/geront/gns003
23. Stahl ST, Schulz R. Changes in routine health behaviors following late-life bereavement: a systematic review. J Behav Med. 2014; 37(4):736-755. doi:10.1007/s10865-013-9524-7
24. Etkin CD, Prohaska TR, Connell CM, Edelman P, Hughes SL. Antecedents of physical activity among family caregivers. J Appl Gerontol. 2008;27(3):350-367. doi:10.1177/0733464808315276
25. Hirano A, Suzuki Y, Kuzuya M, et al. Association between the caregiver’s burden and physical activity in community-dwelling caregivers of dementia patients. Arch Gerontol Geriatr. 2011; 52(3):295-298. doi:10.1016/j.archger.2010.04.011
26. Fredman L, Bertrand RM, Martire LM, Hochberg M, Harris EL. Leisure-time exercise and overall physical activity in older women caregivers and non-caregivers from the Caregiver-SOF Study. Prev Med. 2006;43(3):226-229. doi:10.1016/j.jpmed.2006.04.009
27. Beesley VL, Price MA, Webb PM; Australian Ovarian Cancer Study Group, Australian Ovarian Cancer Study, & Quality of Life Caregiving in the U.S. 2015
28. Von Ka¨nel R, Mausbach BT, Dimsdale JE, et al. Regular physical activity levels, and physical health. Arch Gerontol Geriatr. 2009;49(1):151-157. doi:10.1016/j.archger.2009.05.011
29. Stewart AL, Mills KM, King AC, Haskell WL, Gillis DAWN, Ritter PL. CHAMPS physical activity questionnaire for older adults: outcomes for interventions. Med Sci Sports Exerc. 2001; 33(7):1126-1141. https://bobcat.militaryfamilies.psu.edu/sites/default/files/placed-programs/Stewart%20et%20al,%202001_Questionnaire.pdf.
30. Von Känkel R, Mausbach BT, Dimsdale JE, et al. Physical activity questionnaire for older adults: outcomes for interventions. Med Sci Sports Exerc. 2001; 33(7):1126-1141. https://bobcat.militaryfamilies.psu.edu/sites/default/files/placed-programs/Stewart%20et%20al,%202001_Questionnaire.pdf.
31. Alvarez-Pedrerol J, Lluch S, Vila J, et al. Association between physical activity and cognitive performance in older adults. J Nutr Health Aging. 2004;8(4):312-319. doi:10.1097/01.mna.0000118846.23658.c1
32. Nied RJ, Franklin B. Promoting and prescribing exercise for the elderly. Am Fam Physician. 2002;65(3):419-426. http://www.sld.cu/galleries/pdf/sites/rehabilitacion-ejer/419.pdf.
33. Reuben DB, Wallhagen MI, Blaum CS, et al. Physical activity and health outcomes among caregivers of older adults: a meta-analysis. J Am Geriatr Soc. 2006;54(7):1048-1055. doi:10.1111/j.1532-5415.2006.44462.x
34. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer’s disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer’s Disease. Neurology. 1981;31(3):872-882. doi:10.1212/WNL.31.3.872
35. Folstein MF, Folstein SE, McHugh PR. “Mini-Mental State”: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189-198. http://home.uchicago.edu/~tmurray1/research/articles/print%20and%20read/mini%20mental%20state_a%20practical%20method%20for%20grading%20the%20cognitive%20state%20of%20patients%20for%20the%20clinical.pdf.
36. ADNI. Alzheimer’s Disease Neuroimaging Initiative (ADNI). June 2015. http://www.adni-info.org/research/general-caregiving. Accessed July 2016.
37. Hamilton M. A rating scale for depression. J Neurol Neurosurg Psychiatry. 1960;23(1):56-62. PMID:14399272
38. Spielberger CD. Manual for the State-Trait Anxiety Inventory (Form Y). Palo Alto, CA: Mind Garden; 1983.
39. Hellwig JP, Otten JJ, Meyers LD, eds. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: National Academies Press; 2006.
40. Hellwig JP, Otten JJ, Meyers LD, eds. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: National Academies Press; 2006.
41. American College of Sports Medicine. ACSM’s Guidelines for Exercise Testing and Prescription. 8th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2009.
42. Hellwig JP, Otten JJ, Meyers LD, eds. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: National Academies Press; 2006.
43. Food and Nutrition Board. Dietary Guidelines Advisory Committee. Dietary Guidelines for Americans, 2015.