Factors Associated with Concordance and Variability of Sleep Quality in Persons with Alzheimer's Disease and their Caregivers

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Study Objectives: To describe the day-to-day variation in sleep characteristics and the concordance between nighttime sleep of persons with Alzheimer's disease (AD) and their family caregivers.

Participants: N = 44 community-dwelling older adults with probable or possible AD and their co-residing family caregivers.

Design: Participants wore an Actillume (Ambulatory Monitoring, Inc) for one week and completed an assessment battery to evaluate patient and caregiver mood, physical function, medication use, caregiver behavior management style, and patient cognitive status.

Measurements and Results: Actigraphically derived sleep measures included bedtime, rising time, total time in bed, total sleep time, number of awakenings, total wake time, and sleep percent (efficiency). For each sleep parameter, total variance was determined for between-subject variance and within-subject variance from day-to-day. Sleep concordance was examined using multinomial logistic regression to compare trichotomous patient-caregiver combinations of good and bad sleepers. For both patients and caregivers, between-subject daily variability accounted for more of the variance in sleep than within-subject variability. Patient depression and caregiver management style were significant predictors both for concordant poor sleep (both patient and caregiver with sleep efficiency $\leq 85\%$) and patient-caregiver sleep discordance.

Conclusions: This study provides data that sleep disturbances for persons with AD and their family caregivers vary considerably night to night, and that poor sleep in one member of the caregiving dyad is not necessarily linked to disturbed sleep in the other. Understanding the complex interrelationship of sleep in AD patients and caregivers is an important first step towards the development of individualized and effective treatment strategies.

Keywords: Sleep, nocturnal disturbances, Alzheimer's disease, caregivers, actigraphy

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SLEEP DISTURBANCES ARE AMONG THE MOST CHALLENGING BEHAVIOR PROBLEMS ASSOCIATED WITH ALZHEIMER'S DISEASE (AD), AND ARE A PRIMARY reason that persons with AD are moved into institutional settings.[1,2] Cross-sectional surveys of clinic- and community-based samples suggest that approximately one-third of dementia patients have trouble sleeping, and approximately two-thirds of dementia caregivers complain about their own sleep.[3] However, the causes and patterns of these sleep disturbances are complex and vary widely across individuals.

Causes of sleep problems in dementia patients and caregivers include physiological changes associated with normal, "non-pathological" aging, changes in the hypothalamic suprachiasmatic nucleus (SCN) and other parts of the circadian timing system, and neurodegenerative processes unique to AD or other dementias.[4,5] In addition, a host of other risk factors can potentially affect nighttime sleep, including the effects of comorbid medical and psychiatric illnesses and their treatments; primary sleep disorders such as sleep apnea, restless legs syndrome, or REM behavior disorder; and behavioral or environmental factors such as light, noise, poor sleep habits, daytime physical inactivity, and diet.[6] More recently, genetic risk factors have been implicated in the development of sleep problems in AD.[7,8]

The kinds of sleep disturbances dementia patients and caregivers experience are also highly individualized, ranging from straightforward problems with sleep latency and maintenance, to dementia-specific symptoms such as nocturnal wandering and day-night confusion.[9] The night-to-night variability in sleep observed in chronic insomniacs[10] can be seen in dementia dyads as well (e.g., Figure 1), although this can be overlooked in clinical settings since caregivers are not always reliable reporters of either their own or their demented family member's sleep quality.[11-13]

The current study takes one step towards describing and understanding this complex interrelationship between the sleep disturbances in community-dwelling AD patients and their caregivers. Although previous research has reported on the sleep and rest-activity patterns of dementia patients and caregivers,[13,14] these studies have not focused on persons with identified sleep disturbances nor examined the possible impact of physical or psychological factors on patient and caregiver sleep. Here we report the co-occurrence of sleep problems in patient-caregiver dyads, the variability of these sleep problems across time, and the covariates that appear to contribute to these patterns.

METHODS

Participants

Forty-four community-dwelling persons with dementia and their caregivers participated in a study of sleep disturbances in dementia (the NITE-AD study).[15] Participants in the NITE-AD

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This was not an industry supported study. Dr. Vitiello is on the speaker's bureau for Takeda. The other authors have indicated no financial conflicts of interest.

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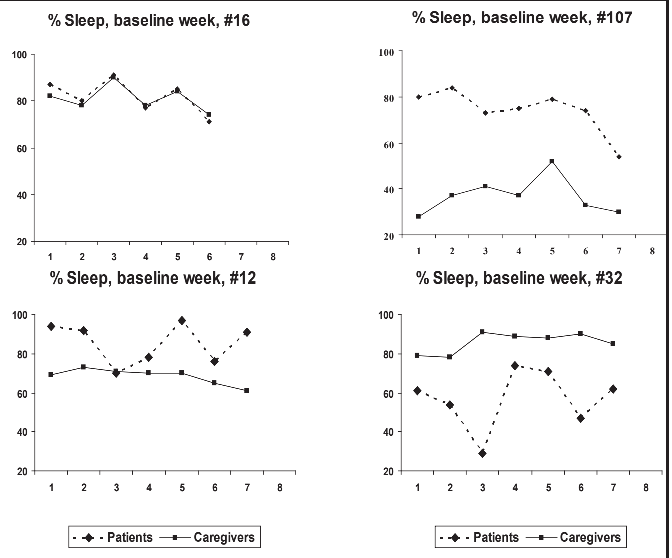

Figure 1—Examples of patient/caregiver sleep percent patterns over one week. Dyads #16 and 107 sleep in same room; dyads #12 and 32 sleep in different rooms.

study were randomized to either a supportive contact control condition or a comprehensive sleep education program that provided information about good sleep practices, caregiver training in behavior management skills, and strategies to increase patient daytime activity and light exposure. The University of Washington IRB approved the study. Written consent was obtained from both patients and caregivers. Additionally, caregivers (next of kin or legal guardians) provided consent on behalf of patients.

The current analyses use data for 44 patient/caregiver dyads, some of whom did not go on to be randomized but who nevertheless completed a baseline (pretreatment) assessment, including at least 4 days of wrist actigraphy. Patients were diagnosed with probable or possible AD, confirmed in writing by their family physicians. They ranged in age from 63 to 93 years, were predominantly white (87%), and had dementia for an average of 5.7 years (SD = 3.2). One-half (50%) of patients were female, and 23% were using sleep medications at the time of enrollment.

Caregivers were adult family members who lived with the patient and could monitor nightly sleep and implement treatment recommendations. Caregivers' ages ranged from 21 to 87 years; 66% were female, and 86% were white. Fifty-seven percent were spouses who slept in the same room as the patient. Twenty percent of caregivers used sleep medications at night. Additional information about participant characteristics is shown in Table 1.

Measures

Sleep

One week of contemporaneous sleep-wake activity was measured for all patient-caregiver dyads using an Actillume wrist-movement recorder (Ambulatory Monitoring, Inc., Ardsley, NY). The Actillume is a matchbox size device worn on the wrist. It contains a piezoelectric linear accelerometer, a microprocessor, 32K-byte random access memory, and associated circuitry for the purpose of recording intensity and frequency of movement. The Actillume also contains a log-linear photometric transducer that records illumination readings from a range below full moonlight to the brightest summer day at noon. The Action3 software package (Ambulatory Monitoring, Inc.), which incorporates Cole and Kripke's[16] sleep scoring algorithm, was used to score sleep/wake. All Actillume sleep variables included in this study were derived from the sum activity channel. Sleep variables included total minutes of nighttime sleep, percent time asleep, number of awakenings, duration of time awake at night, total daytime sleep, and circadian rest-activity variables. Percent nighttime sleep was the focus of this analysis.

The night (in-bed) period was defined as "lights out" at bedtime until the final morning rising (out-of-bed). Sleep diary reports completed by caregivers were used in conjunction with Actillume activity and light data to create the in-bed (nocturnal sleep periods) and out-of-bed (daytime) periods for actigraphic analyses.

Secondary Outcome Measures

Secondary measures included those that we hypothesized would be associated with internight variability in patient and caregiver sleep.[3,17] These included patient and caregiver demographics (age, sex, dementia duration), sleeping medication use, sleeping status (whether or not they shared a room at night), and patient dementia severity as measured by the Mini-Mental State Examination (MMSE).[18]

Patient and caregiver depression and overall health were also included because of their known relationship to sleep in the general population. Patient and caregiver depression was measured using the Cornell Scale for Depression in Dementia (CSDD)[19] and the Center for Epidemiological Studies Depression scale (CES-D),[20] respectively. Analyses using the CSDD and CESD were conducted first using the standard total score, and then compared to results when a modified total score which excluded sleep related items (items 13-15 in the CSDD, and item 11 in the CESD) was used. Since results were identical, results using the original total scores are reported here. The SF-36 Health Status Survey Physical Functioning and Physical Role Functioning subscales[21] measured functional health. Finally, the Dementia Management Strategies Scale (DMSS)[22] was used to rate the frequency with which caregivers use critical, encouraging, and active management strategies to deal with dementia-related behavior problems in their patients. This measure was included because of our previous research that showed its association with caregiver perceptions about patient sleep.[12]

Statistical Methods

Actigraphy data were collected over a one-week period, with up to seven 24-h observation periods for each of the 44 patient-caregiver dyads. Eighty-three percent of patients had available data for all 7 days (mean = 6.8 days, SD = 0.53; range = 4–7 days), and 88% of caregivers had 7 days of data (mean = 6.8 days, SD = 0.59; range = 4–7 days).

Table 1—Baseline Characteristics of Alzheimer's Disease Patients and Caregivers (N =44 dyads)

	Patients		Caregivers		
	Mean (SD)	Range	*Mean (SD)*	Range	P
Demographics					
Age	78.8 (7.2)	63–93	64.6 (15.2)	21–87	<0.001
Education (y)	13.5 (2.9)	8–20	14.9 (2.5)	8–20	<0.001
Duration of dementia (y)	5.7 (3.2)	1–15			
Actigraphy[a]					
Time in bed each night (h)	9.7 (2.2)	3.6–14.1	8.0 (1.1)	5.9–11.1	<0.001
# night awakenings	11.1 (9.6)	<1–41	6.5 (5.2)	1–25	0.001
Total sleep/night (h)	7.9 (2.0)	1.8–14.0	7.1 (1.2)	3.4–8.9	0.03
Total wake time/night (h)	1.9 (1.6)	0.7–7.2	1.0 (1.2)	0.2–6.9	0.01
Percent sleep	81.3 (11.6)	53.3–99.7	88.6 (10.5)	36.7–98.4	<0.001

Note. Comparisons based on paired *t*-tests.

[a] Actigraphic sleep estimates are based on 4–7 days of wrist actigraphy; data presented are the mean of weekly averages for each actigraphy variable.

Data analyses were conducted using Stata (StataCorp 2005; Stata Statistical Software: Release 9; College Station, TX). Between-group comparisons of baseline covariates were conducted using paired *t*-tests and Fisher exact tests. Night-to-night variability was examined separately for patients and caregivers using a variance-components model to differentiate within-subjects night-to-night variance from the between-subject variability.[23] We adjusted for age, sex, and use of sleep medication for both patients and caregivers; we also adjusted for dementia duration in patient analyses.

Patient-caregiver sleep concordance was conceptually defined by a typology of combinations of dichotomous actigraphic sleep outcomes. Patients and caregivers were each classified as having "good" sleep or "bad" sleep based on the average percent of time each night when the individual was in bed and sleeping. Good sleep was defined as average nightly percent sleep >85%, based on meta-analysis data from Ohayon et al.,[24] which indicate that 85% would be a conservative percent sleep estimate for healthy older adults; bad sleep was defined as average nightly percent sleep ≤85%. This classification system produced 4 subgroups: (1) patients–good sleep, caregivers–good sleep (P+C+); (2) patients–poor sleep, caregivers–good sleep (P-C+); (3) patients–good sleep, caregivers–poor sleep (P+C-); and (4) patients–poor sleep, caregivers–poor sleep (P-C-) (Figure 2). Dyads could move from one subgroup to another on different nights, depending upon each individual's percent sleep. To better understand the impact of patient and caregiver characteristics on dyadic sleep status and to maximize power, we focused on night-to-night sleep variability and used lag models to relate dyadic sleep status to lagged values of the previous night's sleep status and other covariates in a parsimonious manner.

Multinomial logistic regression analyses were used to compare categories of patient-caregiver dyad sleep status. In these models the effect of the independent variables are allowed to differ for each outcome category. To account for within-dyad correlation of scores at different time points, robust standard errors were calculated using Stata's cluster option. This sandwich estimator uses a decomposition of the variance that takes into account that the observations within clusters may not be treated as independent, but that the clusters themselves are independent. Empirically, however, we found that only 6% of the dyads in the panel ever fell in the P+C- category (Figure 2). For this reason, we chose to combine this category with the other category (P-C+) where there was a discrepancy between patient and caregiver sleep. This decision was justified by a Wald test for combining dependent categories, which showed that that the P+C- and P-C+ categories were indistinguishable ($\chi^2(11, N = 225) = 14.56$, P = 0.20). Thus, the final results reported are for three groups: dyads that were concordant for good sleep (P+C+), dyads that were concordant for poor sleep (P-C-), and dyads whose sleep was discordant from one another (P+C-, P-C+).

To further examine the factors associated with the relationship between patient and caregiver sleep, two exploratory analyses were also conducted. The first addressed the issue of how best to classify "good" and "bad" sleep. Many patients and caregivers in this study were quite elderly, and had a variety of age-related medical conditions that in addition to dementia diagnosis could

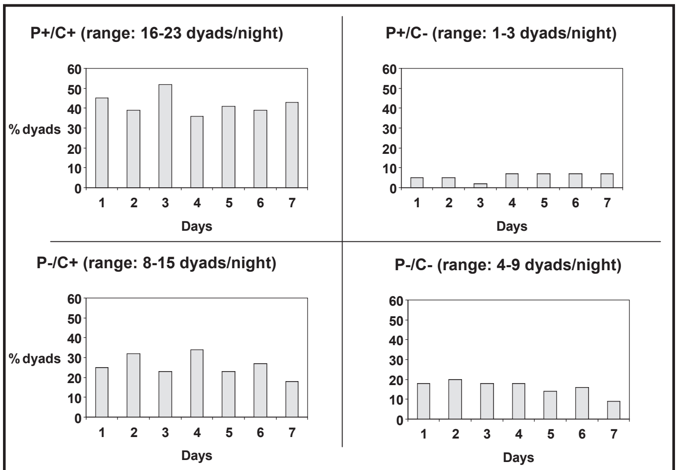

Figure 2—Percent of 44 patient/caregiver dyads where both partners had "good" sleep (P+/C+), both had "bad" sleep (P-/C-), and sleep was discordant (P+/C-; P-/C+) over the sampling week. "Good" sleep = sleep percent > 85%.

impact sleep. Research has shown that older adults with medical morbidity have lower than average sleep efficiencies, at about 80%.[25] For this reason, we examined how study results would change if a sleep efficiency cutoff of 80% (instead of 85%) were to categorize patient-caregiver dyads in the current sample.

The second exploratory analysis addressed how a different list of predictor variables might have influenced study outcomes. Because of sample size and power considerations, we did not include all available NITE-AD self-report data in the current study. For example, we chose depression as a primary caregiver predictive variable rather than burden and stress, because there is a well-established relationship between depression and insomnia,[26,27] and caregiver burden, stress, and depression are all highly correlated. However, burden has been implicated as an important mediator in the development of sleep disturbances in caregivers.[28,29] For this reason, we also subsequently examined how the addition of caregiver burden to regression analyses might impact study results and contribute to our understanding of the phenomenon of discordant sleep in patient-caregiver dyads.

RESULTS

Participant Characteristics

A summary of participants' scores on the primary demographic measures is provided in Table 1. Caregivers were significantly younger ($t(43) = 6.55$, $P < 0.001$); more likely to be women ($P = 0.001$); they awakened less often ($t(43) = 3.54$, $P < 0.001$); and spent less total time in bed than their care-recipients ($t(43) = 4.85$, $P < 0.001$).

Patient average MMSE scores were consistent with a moderately severe dementia level, and both patients and caregivers had mildly elevated levels of depression (Table 2). As expected, patients had significantly lower physical functioning ($t(43) = -8.29$, $P < 0.001$) and physical role functioning ($t(43) = -4.24$, $P < 0.001$) on the SF-36 than caregivers.

Sleep Variability

Table 3 presents the estimated parameters of the variance-components model including the intraclass correlations for actigraphically-derived sleep measures for both patients and caregivers. For patients, the highest night-to-night correlation was bedtime ($\rho = 0.83$) and the lowest was for total sleep per night ($\rho = 0.42$). Interestingly, this differed for caregivers where time in bed had the lowest night-to-night correlation ($\rho = 0.46$), and total wake time per night was the highest night-to-night correlation ($\rho = 0.84$).

In all cases, the standard deviation estimates for both between- and within-subject comparisons were substantially larger than their standard errors, indicating there was significant variation in all sleep measures both between and within subjects. In general, the between-subject variance was greater than the within-subject nightly variance across sleep measures for both patients and caregivers. However, the within-subject nightly variance in total sleep per night for both patients and caregivers was greater than the between-subject nightly variance as reflected in the low to moderate night-to-night correlation values of $\rho = 0.50$ and $\rho = 0.48$ for patients and caregivers, respectively. In addition, the within-subject nightly variance for caregiver time in bed was similar to but still greater than the between-subject variance. There were no significant group effects related to subject age, sex, or sleeping medication use among patients. Among caregivers, males had less total sleep per night ($P = 0.003$) and lower sleep efficiency ($P = 0.04$), and older caregivers spent less time in bed ($P = 0.04$).

Table 2—Assessment Measures for Alzheimer's Disease Patients and Caregivers (N=44 dyads)

	Mean (SD)	**Range**
Patient		
Mini Mental Status Exam	12.6 (8.4)	0–29
Cornell Scale for Depression in Dementia	8.9 (5.2)	1–24
SF-36 Health Status Survey		
Physical Functioning	35.4 (29.3)	0–95
Physical Role Functioning	29.5 (38.6)	0–100
Caregiver		
Center for Epidemiological Studies-Depression	13.4 (9.0)	1–35
SF-36 Health Status Survey		
Physical Functioning	81.4 (20.6)	10–100
Physical Role Functioning	64.8 (40.1)	0–100
Screen for Caregiver Burden		
Objective	11.2 (3.6)	2–18
Subjective	21.2 (9.2)	2–48
Dementia Management Strategies Scale		
Criticism	23.6 (6.1)	12–43
Encouragement	27.1 (5.7)	16–38
Active Management	35.9 (5.0)	14–43

Note. Patient measures except the MMSE based on caregiver (proxy) reports.

Patient/Caregiver Sleep Concordance

Multinomial logistic regression was used to evaluate the relationship between assessment and demographic variables and the concordance of patient and caregiver sleep over the week. The 3 sleep classification categories were: concordant good sleepers (percent sleep >85% for both patients and caregivers, P+C+); concordant poor sleepers (low percent sleep ≤85% for both patients and caregivers, P-C-); and discordant sleepers (combined groups with low percent sleep for either patient or caregiver but not both, P+C-/P-C+). The analysis allowed for the determination of the independent effects of the specific variables of interest holding all other variables constant. Table 4 reports the coefficients for the effect of each independent variable on each category (P-C- and mixed) relative to the comparison category (P+C+).

Comparisons of concordant dyads in the poor sleep classification group to those in the good sleep classification group are shown in the first panel of Table 4. Significant risk factors for poor sleep in patients whose caregivers were also sleeping poorly included increased dementia severity (as measured both by duration of dementia diagnosis and lower MMSE score), increased depression, and poorer physical functioning on the SF-36. Results were identical when the short CSDD scale (minus sleep

Table 3—Variance Components for Patients and Caregivers

	ρ	Between subject SD (SE)	Between subject 95% CI	Within subject SD (SE)	Within subject 95% CI
Patients (n = 44)					
Bed Time	0.82	1.64 (0.19)	1.30, 2.06	0.76 (0.03)	0.70, 0.83
Rising Time	0.63	1.32 (0.16)	1.03, 1.68	1.02 (0.04)	0.93, 1.11
Percent Sleep	0.56	11.12 (1.42)	8.66, 14.29	9.81 (0.44)	8.98, 10.72
Total Wake time/night	0.66	1.35 (0.16)	1.06, 1.72	0.97 (0.04)	0.89, 1.06
Time in bed	0.56	2.14 (0.27)	1.67, 2.75	1.89 (0.08)	1.73, 2.06
# night awakenings	0.81	9.79 (1.15)	7.77, 12.33	4.73 (0.21)	4.32, 5.16
Total Sleep/night	0.50	1.88 (0.25)	1.45, 2.44	1.89 (0.08)	1.73, 2.07
Caregivers (n = 44)					
Bed Time	0.58	1.11 (0.14)	0.87, 1.42	0.94 (0.04)	0.87, 1.42
Rising Time	0.66	1.04 (0.12)	0.82, 1.32	0.75 (0.03)	0.69, 0.82
Percent Sleep	0.78	10.06 (1.17)	8.01, 12.64	5.34 (0.24)	4.89, 5.84
Total Wake time/night	0.84	0.96 (0.11)	0.77, 1.20	0.41 (0.02)	0.38, 0.45
Time in bed	0.46	1.00 (0.13)	0.77, 1.30	1.09 (0.05)	1.00, 1.19
# night awakenings	0.68	5.01 (0.60)	3.96, 6.34	3.41 (0.15)	3.12, 3.72
Total Sleep/night	0.48	1.00 (0.13)	0.78, 1.30	1.05 (0.05)	0.96, 1.14

Note. ρ = intraclass correlation coefficient; SD = standard deviation; CI = confidence interval.

related items) was used to measure patient depression. Patients who were taking sleeping medications were 6 times more likely to have poor sleep than those who did not take sleeping medications. Surprisingly, higher (better) physical *role* functioning on the SF-36 was also associated with poor patient sleep.

For caregivers in the concordant group, poor caregiver sleep was associated with poor sleep the previous night and higher use of encouragement as a behavior management strategy. Male caregivers had an almost 9-fold increased risk for having poor sleep when the patient was sleeping poorly than did female caregivers.

When dyads in the combined group of discordant patients and caregivers (P+C-, P-C+) were compared to those in the concordant good sleep group (P+C+), only increased patient depression predicted patient membership in one of the 2 discordant categories. For caregivers, all 3 subjective styles of managing patient behaviors were significantly related to sleep classification. Use of encouragement was associated with discordance in caregiver and patient sleep, and use of criticism or active problem solving was associated with concordance in caregiver and patient sleep.

In both sets of comparisons, patient or caregiver age, sharing a room, and caregiver depression and health were not significant predictors of dyadic sleep classification.

Exploratory Analyses

As would be expected, when analyses were repeated using a percent sleep cutoff of 80% to distinguish good and bad sleepers, the distribution of patient-caregiver dyads across the 3 classification categories changed (results not shown). Most notably, the total number of dyads that fell into the concordant poor sleep (P-C-) group decreased by almost one-half (previously N = 50 across the entire week was reduced to N = 30 dyads), resulting in a reduced power to identify significant risk factors. Nevertheless, the pattern of results was similar to that found in the original regression analyses. Significant risk factors for poor sleep in patients whose caregivers were also sleeping poorly included increased dementia severity, poorer physical functioning, and sleep medication use. For caregivers, male gender, poor sleep the night before, and elevated use of criticism were predictive of poor sleep. Poor sleep the previous night and criticism were also predictive of discordant caregiver sleep. The most notable difference in results was that patient depression no longer appeared as a significant predictor in the repeat analyses. In other words, fewer risk factors were identified when a more strict classification of poor sleep was used, but variables that were significant were in the same direction and comparable to those found originally.

When analyses were repeated adding caregiver burden to the original list of predictor variables, results were slightly different although not incompatible with the original findings. When burden was added, patient concordant poor sleep was associated with patient dementia duration, depression, increased use of sleep medications, and lower level of physical function. Caregivers in this concordant poor sleeper group were less likely to be using sleep medications, and more likely to have slept poorly the night before compared to dyads where both patient and caregiver were sleeping well, but significant gender differences disappeared. Caregivers were also less prone to use criticism as their primary strategy for managing dementia-related behavior problems, in contrast to previous findings showing that they were more likely to use encouragement. For discordant dyads, increased patient depression, caregiver management style (more encouragement, less criticism and active problem solving), and caregiver sex (male) all predicted membership, as had been the case in the original results.

DISCUSSION

This investigation examined the co-occurrence of sleep problems in patient-caregiver dyads, the variability of these

Table 4—Relative Risk Ratios for a Multininomial Logit Model of Patient and Caregiver Sleep Efficiency

	Relative Risk Ratio	95% Confidence Interval	P
Comparison: P-C- vs P+C+			
Patient			
Previous night sleep percent	0.98	0.94, 1.03	0.45
Age	1.09	0.95, 1.25	0.20
Sex[a]	1.00	0.13, 7.54	0.99
Duration dementia	1.46	1.14, 1.87	0.003
Mini Mental Status Exam	0.88	0.78, 0.99	0.02
Sleep medication use[b]	6.63	1.15, 38.22	0.03
Cornell Depression Scale	1.24	1.07, 1.45	0.005
SF-36 Physical functioning	0.94	0.89, 0.99	0.03
SF-36 Physical role functioning	1.04	1.02, 1.08	0.002
Caregiver			
Previous night sleep percent	0.81	0.73, 0.90	<0.001
Age	1.04	0.96, 1.12	0.37
Sex[a]	8.76	1.35, 56.70	0.02
Sleep medication use[b]	0.50	0.02, 10.16	0.65
Center for Epidemiological Studies Depression scale	1.03	0.92, 1.16	0.61
SF-36 Physical functioning	1.02	0.98, 1.06	0.32
SF-36 Physical role functioning	0.99	0.97, 1.01	0.30
Dementia management:			
criticism	0.90	0.76, 1.06	0.20
encouragement	1.21	1.01, 1.46	0.04
Dementia management: active	0.84	0.66, 1.06	0.14
Patient/caregiver share room	0.73	0.04, 13.24	0.83
Comparison: Discordant (P+C-, P-C+) vs P+C+			
Patient			
Previous night sleep percent	0.97	0.94, 1.01	0.12
Age	1.02	0.96, 1.08	0.54
Sex[a]	1.32	0.46, 3.78	0.60
Duration dementia	1.07	0.96, 1.19	0.22
Mini Mental Status Exam	1.00	0.96, 1.05	0.88
Sleep medication[b]	2.70	0.87, 8.32	0.08
Cornell Depression Scale	1.14	1.02, 1.26	0.01
SF-36 Physical functioning	0.98	0.97, 1.00	0.09
SF-36 Physical role functioning	1.00	0.99, 1.02	0.54
Caregiver			
Previous night sleep percent	0.95	0.89, 1.02	0.16
Age	1.00	0.95, 1.04	0.83
Sex[a]	2.48	0.84, 7.31	0.09
Sleep medication use[b]	0.70	0.25, 1.94	0.49
Center for Epidemiological Studies Depression scale	1.05	0.99, 1.11	0.07
SF-36 Physical functioning	1.01	0.99, 1.04	0.24
SF-36 Physical role functioning	1.00	0.98, 1.01	0.62
Dementia management:			
criticism	0.87	0.79, 0.96	0.004
encouragement	1.14	1.03, 1.27	0.01
active	0.84	0.76, 0.93	0.001
Patient/caregiver share room	1.43	0.47, 4.34	0.52

[a] Referent group is no use of sleep medication.

[b] Referent group is female.

sleep problems across time, and the covariates that appear to contribute to these patterns. In contrast to Knutson's[23] study of actigraphic sleep patterns of middle-aged adults, between-subject variability accounted for more of the variance in both patient and caregiver sleep than within-subject nightly variability. However, the sleep variables that showed the greatest night-to-night stability and variability differed between patients and caregivers. The greatest stability for patients was observed for the time of night when they went to bed, which had a night-to-night correlation of 0.82 and a within-subject standard deviation of 0.76, which is equal to approximately 46 min (Table 3). For caregivers, the greatest stability was total wake time at night, with a within-subject standard deviation of about 25 min and a night-to-night correlation of 0.84. The least stable patient sleep variable was total hours sleep per night, which had a night-to-night correlation of 0.50 and a within-subject standard deviation of about 1.9 h. Time in bed was the least stable variable for caregivers, with a within-subject standard deviation of approximately 65 min and a night-to-night correlation of 0.46.

When participants were classified into "good" or "bad" sleepers based upon night percent sleep time, there was a sizable number (between 25% and 41%) of dyads on any given night whose sleep was discordant, that is, one person was sleeping well and one person was sleeping poorly with, in some cases, the poor sleeper being the caregiver. This was true whether a cut point of either 80% or 85% was used to define good sleep. Dyads where both caregiver and care-recipient were sleeping poorly over a 7-night sampling period were more likely to be those in which patients had a lower level of physical function, were more severely demented, and using more sleep medications. Caregivers in the concordant poor sleeper group were more likely male, and more likely to have slept poorly the night before. Patient depression was a significant risk factor in both concordant and discordant analyses when a sleep efficiency of 85% was used to define good sleep, but was not significant when 80% was used.

Surprisingly, patient or caregiver age, sharing a room, and caregiver depression and health were *not* significant predictors of either concordant poor sleep or discordant sleep patterns. Caregiver sleeping medication use was also not related to discordant sleep. These findings suggest that the development and maintenance of sleep problems in dementia patient/caregiver dyads is more complex than is generally recognized.

Results from this study have potentially important implications for clinicians working with co-residing dementia patients and caregivers. First, sleep medications are not necessarily helpful. Dyads where both caregiver and care-recipient were sleeping poorly were more likely to include patients who were using sleep medications, but discordant sleep (where one person was sleeping well and the other was not) was not associated with medication use in either patients or caregivers. It was also the case that having separate bedrooms was not associated with concordant or discordant sleep, a finding which seems counter-intuitive and many may find surprising.

Patient depression was a significant risk factor for both concordant poor sleep and discordant sleep in our original analyses. This finding is consistent with other studies that have highlighted the importance of identifying and treating comorbid sleep disruption and depression in elderly dementia patients and caregivers.[17,30] Future studies are needed to determine whether the absence of depression as a significant predictor in the exploratory analysis using an 80% cut point is an artifact of reduced power in the analyses, or a true difference related to a more stringent classification of bad sleep. Both patients and caregivers also had moderate within-subject variance in their total nightly time in bed and morning rising times, which suggests that evidence-based nonpharmacological treatments for insomnia that emphasize sleep restriction and stabilization of bed and rising times[31] may be potentially efficacious in this population.

There are limitations to this study. The sample size was relatively small. However, actigraphic sleep data were available for most patients and caregivers over a 7-day period, greatly increasing the robustness of analytic comparisons, and given this is the first study of its kind, this was an adequate sample upon which to build future inquiry. We chose to use nightly average percent sleep as our comparison criterion, following a convention of 85% as defining "normal sleep," and used a set of predictive variables that we hypothesized would be related to sleep in our patient and caregiver samples. Using different analysis variables or criteria for good and bad sleep might lead to different conclusions. However, our exploratory analyses using a sleep efficiency cut point of 80% and adding burden to the variable list yielded results that were comparable to our original findings. We were restricted to use of predictive outcomes that were collected at the beginning of the actigraphy sampling week. Future studies exploring similar questions about factors influencing sleep variability and concordance in patients and caregivers might consider collecting daily mood and behavioral information that would be contemporaneous with sleep quality estimates.

Finally, future research looking at nightly sleep variability in AD patients and caregivers would greatly benefit from evaluation for primary sleep disorders. In the NITE-AD study, proxy caregivers did complete the sleep apnea subscale of the Sleep Disorders Questionnaire about the patient,[32] and only 2 patients scored in the upper 25th percentile of the scale, suggesting that much of the nightly variability in sleep was not due to sleep disordered breathing. However, more structured assessment of SDB or other primary sleep disorders would help clarify the role it plays in patient-caregiver sleep concordance.

In summary, this study provides data that sleep disturbances for both persons with dementia and their family caregivers vary considerably night to night, and that poor sleep in one member of the caregiving dyad is not necessarily linked to disturbed sleep in the other. We believe this to be the first study that has attempted to look at the psychosocial factors associated with variability and concordance of sleep in dementia dyads. Our analyses suggest that dyads in which both patient and caregiver are sleeping poorly may be those in which the overall caregiving situation is more difficult: it may have been going on for a longer period of time, the patient has more physical and psychological morbidity, and the caregiver does not have an effective approach for dealing with the situation. Our research team is currently conducting a larger study looking at treatments for sleep disturbances in Alzheimer disease; future analyses with the benefit of a larger sample size will help explore these important questions more effectively. Nevertheless, our approach does provide a first attempt to begin to describe the complex interrelationship of sleep in persons with dementia and the family members who provide their care. This is key to the development of individualized and effective treatment strategies.

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