Effect of Employment Status on the Association Among Sleep, Care Burden, and Negative Affect in Family Caregivers

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1 **Effect of Employment Status on the Association among Sleep, Care**

2 **Burden, and Negative Affect in Family Caregivers**

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19   **ABSTRACT**

20 **Objective:** To examine the effect of employment status on sleep, care burden,

21 and negative affect among family caregivers (FCs) at home.

22 **Methods:** An intensive longitudinal design was applied in which 25 FCs

23 underwent in-home assessments for up to 56 days. At baseline, demographic

24 data and employment status were collected. FCs wore a wrist-worn device with

25 an accelerometer to assess objective total sleep time (TST) for consecutive 24-

26 hour periods. FCs answered the Zarit Burden Interview (ZBI) and Positive and

27 Negative Affect Schedule (PANAS) every night before sleep. Linear mixed model

28 analysis was used to examine the effect of objective sleep status on ZBI and

29 PANAS scores the following day.

30 **Results:** Mean participant age was 66.3 ± 10.8 years (72.0% female), and mean

31 survey period was 29.1 ± 9.6 days (866 observations). Mean TST of FCs was 5.7

32 ± 1.4 hours. In total, 32.0% of FCs were employed either full- or part-time. TST of

33 employed FCs was significantly associated with care burden and negative affect

34 (B = −0.4 and −1.3, respectively); however, positive affect was not associated

35 with TST. FCs who were unemployed experienced less care burden and negative

36 affect (rate of change: −7.7 and −8.0, respectively). Additionally, TST of

37   unemployed FCs was associated with negative affect; thus, when they slept one

38   hour longer than their mean TST, they experienced less negative affect the

39   following day.

40   **Conclusion:** A reduction in TST could lead to increased care burden and more

41   severe negative affect the following day, which may be moderated by

42   employment status.

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44   KEYWORDS: family caregiver, care burden, negative affect, employment status,

45   sleep, long-term care

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Introduction

Providing informal care to a family member often compromises caregivers' mental and physical health, including sleep status.[1-8] Previous studies have reported that poor sleep is linked to many other health problems for family caregivers (FCs), such as depression, care burden, poor subjective well-being, and cardiovascular disease.[6,8,9] However, there is limited research about the intensive longitudinal effects of objective sleep status on care burden and negative and positive affect the following day, or the moderating factors of these associations.[2,8] One previous study that analyzed the relation between sleep status and positive affect suggested that elevated levels of positive affect were longitudinally associated with better subjective sleep status but not objective sleep status, as measured by a wrist-worn device with an accelerometer for consecutive three-day periods.[8] Although other studies have measured sleep status of FCs for one night or over a few days to examine the relationship between objective sleep status and care burden, it has been a challenge to calculate representative values of objective sleep status under home care conditions that cause variations in the sleep status of FCs.[2,6] If daily sleep variabilities could be objectively measured for a longer period than in previous studies, the relationship between objective sleep status,

73　care burden, and positive and negative affect might be clarified, helping to fill a

74　gap left by previous studies.

75　　　FCs play many roles in addition to caring for those requiring care. The

76　employment rate of middle-aged FCs is increasing in Japan,[10] therefore, it is an

77　urgent task for FCs to provide support that allows nursing care to continue at

78　home while working. Recent studies have evaluated associations among

79　employment status and objective sleep status, and findings suggest some

80　nonlinear effects of employment status on the associations between sleep and

81　fatigue, such as negative affect in FCs.[11,12] One study was guided by the Work,

82　Nonwork, and Sleep framework.[12] This framework characterizes longer sleep

83　duration and better sleep quality as factors that regenerate physical energy and

84　that are related to the capacity to work and provide care.[11] However, few studies

85　have examined the naturally occurring association between sleep and care

86　burden in the context of FCs' employment status in Japan. Based on the Work,

87　Nonwork, and Sleep framework and the presented empirical evidence, we set a

88　hypothesized model of factors influencing care burden and negative affect

89　among FCs as the conceptual framework for this study (Figure 1), comprising

90　the following two hypotheses:

91   H1: total sleep time (TST) the previous day negatively predicts care burden and

92   negative affect the following day;

93   H2: employment status of FCs is a moderator and boosts the negative

94   association between sleep, care burden, and negative affect the following day.

95   [Figure 1 near here]

96   As the number of people requiring care rapidly increases in Japan and

97   other super-aged nations, more FCs continue to take care of their relatives while

98   remaining employed. Additionally, the number of FCs who provide home care in

99   Japan has consistently been increasing, reaching about 7 million in 2016, and

100   the number of middle-aged FCs and the time required for caregiving have also

101   increased.[10] At the same time, more than 40% of FCs are engaged in work other

102   than taking care of relatives.[10] Thus, it is an urgent task to examine how

103   employment status plays a role in the associations between sleep, care burden,

104   and negative affect. Therefore, the purpose of this study was to examine the

105   effect of employment status on objective sleep status, care burden, and negative

106   affect among FCs in their homes.

107

108   **Methods**

Study design and participants

110   The current study was part of an intensive longitudinal survey conducted from

111   February 2017 to March 2019 that investigated the health and objective sleep

112   status of FCs in a home care setting.[9] Participants constituted 25 dyads of primary

113   FCs and care receivers (CRs) living together, recruited from three day-service

114   providers and one nursing home respite service in a general residential area in

115   Osaka, Japan. CRs were aged 65 years and older and under the long-term care

116   insurance system in Japan. We conducted the survey while CRs were not using

117   the respite service to ensure that data were collected while FCs and CRs spent

118   time at home together. At the baseline survey, the 25 dyads participated for 14

119   consecutive days. At three months, six months, and one year after the baseline

120   survey, this study followed the same protocol. The objective sleep measures were

121   collected at these intervals for 14 consecutive days each time; however, one CR

122   died and three CRs were hospitalized after the baseline survey. Thus, after the

123   baseline survey, 21 dyads participated until their CRs died, were hospitalized, or

124   it became too difficult for FCs to continue participation. Of those, 11 dyads

125   participated for 28-29 days, four dyads participated for 42-44 days, and six dyads

126   participated for 54-56 days; therefore, the data collection period was between 14

127 and 56 days for all dyads.

128 **Measurements**

129 In the baseline survey, age; sex; level of care required (national standard for care

130 needs was determined by assessing applicants' severity of physical disability and

131 dementia: care levels 1-5, ranging from the lowest to the highest care needs

132 level); CRs' assistance requirement regarding moving, bathing, eating, and

133 toileting; CRs' age at care service use onset; duration of care service use; and

134 clinical history were collected.[13,14] Both FCs and CRs were asked if they had ever

135 been told by a physician that they had dementia, with answers coded as yes or

136 no. Current employment information of FCs was collected regarding work status

137 (full-time, part-time, or non-worker, including retirement). FCs' working hours per

138 day, working days per week, and duration of current work were also collected at

139 baseline.

140 *Sleep Measurement*

141 After the baseline survey, objective sleep status was measured using an

142 ActiGraph GT9X (ActiGraph, Florida, USA), which was worn for consecutive 24-

143 hour periods for between 14 and 56 consecutive days on FCs' non-dominant wrist.

144 Actigraphy has been validated and recommended for use among elderly

145 populations and has been compared favorably with polysomnography, which is

146 considered the "gold standard" for sleep assessment.[15-18] Recorded actigraphy

147 data were analyzed using ActiLife software (version 6, by ActiGraph, Florida,

148 USA). The following sleep parameters were calculated across time periods: (1)

149 TST; amount of time spent sleeping in minutes); (2) total time in bed (amount of

150 time spent in bed between in-bed and final out-of-bed times of nocturnal sleep

151 period in minutes); (3) sleep efficiency (ratio of total sleep time to total time in

152 bed); and (4) wake after sleep onset at night between initial sleep onset and final

153 awakening.

154 The Japanese version of the Pittsburgh Sleep Quality Index (PSQI) was

155 used as a baseline assessment to quantify subjective sleep disturbance in FCs

156 and CRs.[19,20] PSQI scores range from 0 to 21, with PSQI scores of 5 or greater

157 indicating clinically significant sleep disturbance. The Cronbach's alpha of the

158 PSQI has been calculated as 0.83, and its construct validity has also been

159 verified.[19]

160 *Other Factor Measurements*

161 The following factors were measured at baseline and three months, six months,

162 and one year after baseline. The mean scores of the following measurements

163 were calculated in this study.

164 The well-being of FCs and CRs was measured using the Japanese version

165 of the WHO-Five Well-being Index (WHO-5), at baseline and three months, six

166 months, and one year after baseline.[21] The scale consists of five items. Scores

167 range from 0 to 25, and higher scores indicate better well-being. The Cronbach's

168 alpha of the WHO-5 has been calculated as 0.87, and its construct validity has

169 also been verified.[21]

170 Depressive mood was assessed for both FCs and CRs using the 15-item

171 Geriatric Depression Scale (GDS-15).[22] The GDS-15 is a questionnaire

172 specifically developed to screen for and assess depression in the elderly.[22,23] The

173 Cronbach's alpha of the GDS-15 has been calculated as 0.87, and its construct

174 validity has also been verified.[22]

175 **Assessment of care burden and positive and negative affect**

176 Caregiver burden was assessed using the short version of the Zarit Caregiver

177 Burden Interview (ZBI_8).[24,25] It is a commonly used measure of care burden and

178 has been utilized with older adults.[9] Total scores range from 0 to 32, and higher

179 scores indicate a more severe care burden. The Cronbach's alpha of the ZBI_8

180 has been calculated as 0.93, and its construct validity has also been verified.[24]

181   FCs' positive affect, such as the feeling of happiness, cheerfulness, and

182 enjoyment, and negative affect, such as the feeling of distress, hostility, and fear,

183 they felt at the moment the survey was given were assessed using the Positive

184 and Negative Affect Schedule (PANAS).[26,27] The Cronbach's alpha of positive and

185 negative affect has been calculated as 0.90 and 0.91, respectively, and the

186 PANAS has shown good validity in older adults.[8,26,28] FCs rated 10 items each for

187 both negative and positive affect on a 5-point scale ranging from 1 (very slightly

188 or not at all) to 5 (extremely). The total score was calculated from 10 to 50 for

189 either scale. FCs answered the ZBI_8 and PANAS every night before going to

190 bed during the study period.

191 **Statistical analyses**

192 Sociodemographic and clinical characteristics were expressed as means,

193 standard deviations, and percentages. They were calculated after excluding

194 those with missing data. Spearman's rank correlation analysis was performed

195 between objective and subjective sleep parameters, care burden, and positive

196   and negative affect. The current employment status of FCs was used to stratify

197   their employment status as groups: those who were employed (full-time or part-

198   time) and those who were unemployed (non-worker, including retirement).

199   Differences between employed and unemployed FCs were obtained using Mann-

200   Whitney U-tests for continuous variables and Fisher's exact tests for dichotomous

201   variables. A mixed model using data across the entire study period was run for

202   caregiving burden and positive and negative affect using ZBI_8 and PANAS

203   scores as dependent variables. The model estimated an intercept and slope for

204   each FC based on all available data for that individual, augmented by data from

205   the entire sample. TST was centered by overall mean. Slopes indicated the rate

206   of change for one hour of TST. Employment status indicated FCs who worked a

207   full- or part-time job during the day. A dummy variable was based on employment

208   status and showed the rate of change for FCs who were unemployed. Slope

209   estimates indicated non-standardized coefficients in the models. Statistical

210   analysis was performed using SPSS 25 (IBM Japan). A probability value of $P <$

211   0.05 was considered statistically significant.

212   This study was approved by the internal review board of the Graduate

213   School of Health Sciences, Kobe University (approval numbers 544 and 720),

214 conforming to the provisions of the Declaration of Helsinki. After receiving a

215 complete description of all procedures for this study, all CRs and FCs provided

216 written informed consent.

217

218 **Results**

219 **Participant characteristics**

220 The mean survey period was 29.1 ± 9.6 days (866 observations). The mean age

221 was 66.3 ± 10.8 years for FCs and 82.8 ± 8.2 years for CRs, and 72.0% of FCs

222 and CRs were female (Table 1). Mean ZBI_8, positive affect, and negative affect

223 scores during the survey were 7.3 ± 6.8, 19.8 ± 8.4, and 16.1 ± 6.4, respectively.

224 Of those, 41.6% of FCs and 55.6% of CRs scored above the GDS-15 threshold

225 of 5, indicating depressive mood. Mean TST of FCs was 5.7 ± 1.4 hours per day.

226 Regarding CRs who required moving assistance, 24.0%, 36.0%, and 40.0%

227 needed assistance because they were bedridden, used a wheel chair, or were

228 ambulatory, respectively. Further, 76.0%, 60.0%, and 80.0% of CRs needed

229 bathing, eating, or toileting assistance, respectively. FCs who worked full- or part-

230 time totaled 32.0%. Of those, working hours per day, working days per week, and

231 duration of current work were 5.2 ± 1.9 hours, 3.6 ± 1.0 days, and 9.3 ± 5.9 years,

232   respectively. Age, ZBI_8 scores, TST, and total time in bed showed significant

233   differences between FCs who were employed and those who were unemployed.

234   FCs who were employed were significantly younger, felt a severe care burden,

235   slept for shorter periods of time, and spent less time in bed than unemployed FCs,

236   but there were no significant differences between employed and unemployed FCs

237   regarding FCs' positive and negative affect; FCs' and CRs' GDS-15, WHO-5 Well-

238   Being, and PSQI scores; and CRs' assistance required for moving, bathing,

239   eating, and toileting. Finally, there was a significant correlation between FCs'

240   PSQI and ZBI_8 scores (Supplemental Table 1), whereas no significant

241   correlation was found between PSQI and positive and negative affect.

242   [Table 1 near here]

243   **Changes in main outcomes**

244   Figure 2 shows the model-predicted change of care burden (top) and negative

245   affect (bottom) in terms of TST and the between-person differences according to

246   FCs' employment status. As indicated by the solid line, employed FCs' care

247   burden and negative affect were higher than those of unemployed FCs on

248   average. Additionally, TST had a negative effect on care burden; thus, a longer

249   TST of FCs who worked full- or part-time was associated with lower ZBI_8 scores.

250   [Figure 2 near here]

251   **Moderation effect of employment status**

252   The results of a fitted multilevel model for changes in scores for the ZBI_8,

253   positive affect, and negative affect were as follows: TST of FCs who were

254   employed was significantly associated with ZBI_8 and negative affect scores (B

255   = −0.41 and −1.30, respectively); positive affect scores were not associated with

256   TST. FCs who were unemployed and with average TST experienced significantly

257   less care burden (rate of change: −5.7; Table 2). Additionally, TST of unemployed

258   FCs was associated with negative affect: on days when they slept one hour longer

259   than their mean TST, they experienced less negative affect the next day (rate of

260   B change: 1.45). As seen in Table 1, mean age was significantly different between

261   employed and unemployed FCs; therefore, the same multilevel model was used

262   to determine changes in ZBI_8, positive affect, and negative affect scores

263   according to age (Supplemental Table 2). Results showed the TST of FCs 65

264   years old or younger was not significantly associated with ZBI_8 or positive or

265   negative affect scores; however, on days when elderly FCs slept one hour longer

266   than their mean TST, they experienced less care burden the next day (rate of

267   change: −0.72).

268   [Table 2 near here]

269   **Discussion**

270   The purpose of this study was to examine the effect of employment status on

271   objective sleep, care burden, and negative affect among FCs at home. This study

272   showed the intensive longitudinal effect of objective sleep status from the

273   previous day measured at multiple points, between 14 and 56 days, on care

274   burden and negative affect, as moderated by FCs' employment status. It found

275   that a more severe care burden was significantly associated with poorer TST, as

276   objectively measured. This is consistent with our cross-sectional results at

277   baseline.[9] Additionally, to the best of our knowledge, this study was the first to

278   demonstrate that a reduction in TST could lead to more severe negative affect for

279   FCs the following day, which might be moderated by employment status. The use

280   of the intensive longitudinal method allowed novel associations to be determined;

281   the findings imply it would be important for FCs who work to sleep and get enough

282   rest at night.

283   A few nights of actigraphy may not be representative of habitual sleep

284   status for FCs. Notably, this study used data covering 14 to 56 days of actigraphy

285   to objectively measure sleep, while previous studies that reported no significant

286   correlations between sleep and physical/psychological conditions often based

287   their sleep measurements on a few nights of actigraphy or self-report.[1,3,4,6,8,29]

288   Sleep parameters in this study also considered sleep variability, as sleep for FCs

289   might be affected by not only unexpected nighttime care involving, for example,

290   tending to CRs' behavioral and psychological symptoms of dementia, but also

291   various daytime incidents such as FCs' overtime work and CRs' physical

292   condition. This study thus considered the day-to-day variability of sleep, care

293   burden, and negative affect, and inter-individual differences in intra-individual

294   changes were taken into account.

295   However, in this study, no significant association was found between

296   positive affect and objective and subjective sleep status. Positive affect of FCs in

297   this study might have been influenced by factors other than home care. One

298   previous longitudinal study has suggested that positive affect has stronger

299   associations with subjective sleep measured by the PSQI than with objective

300   sleep measured by actigraphy.[8] On the other hand, this study did not collect

301   subjective sleep data longitudinally. Therefore, the current study clarifies that a

302   longer sleep time does not necessarily increase positive affect, but whether

303 positive feelings toward sleep quality enhance positive affect remains unclear.

304   A novel finding of the current study was that employment status of FCs

305 moderated the association between TST, care burden, and negative affect, as

306 few previous studies have considered FCs' employment status.[6] The social

307 background of FCs who take care of relatives at home is diverse, and it may be

308 that many FCs worked more, thus shortening their sleep hours. Although we did

309 not collect information on type of employment or when and how long FCs worked,

310 this study suggests the importance of providing support for FCs who work while

311 caring for a relative at home.

312   Despite its novel approaches, this study had several limitations. First,

313 the sample size was small, so the findings may not be generalizable to larger

314 populations even though 25 FCs were able to participate in at least two

315 consecutive weeks of the survey. During the longitudinal study that the current

316 study was a part of, some CRs in the study area were hospitalized after

317 participating in the study and had subsequently died at follow-up of three, six

318 months later; therefore, it was difficult to increase the sample size.[9] Additionally,

319 32% of FCs (i.e., fewer than 10 participants) were employed; this might lead the

320 results to seem more impactful than they actually are. Furthermore, it was difficult

321   to adjust for other confounding factors in the mixed models, and we could not

322   perform a stratified analysis based on the family relationships between the FCs

323   and CRs and the FCs' working hours. All FCs who were employed were children

324   of the CRs; therefore, differences in family relationships might be related to our

325   results of the influence of employment status on care burden and negative affect.

326   In fact, the differences among FCs' working hours per day, working days per week,

327   and duration of current work could not be adjusted for in the mixed model

328   because of the small sample size. Differences in the influence of employment

329   status on care burden might depend on the amount of working hours per week

330   and working days per month; therefore, taking these data into consideration

331   would help determine whether the results can be generalized. Additionally,

332   differences in the number of follow-up times per individual may have influenced

333   the results. Second, the test for the level-1 residual variance suggested the

334   existence of additional outcome variation at level-1, which may have been

335   predictable. To explain some of this remaining within-person variation, we might

336   add suitable time-varying predictors, such as working time, amount of nighttime

337   care, or amount of FC-CR interaction, to the level-1 sub-model. Additionally, level-

338   2 residual covariance indicated that the intercepts and slopes of individual true

339   change trajectories were correlated; thus, we could not clarify several

340   associations between true initial TST and true annual rate of change after

341   controlling for the effect of employment status. Third, there were age differences

342   between employed and unemployed FCs (unemployed FCs were older), although

343   the TST of FCs 65 years old or younger was not significantly associated with

344   ZBI_8 or positive or negative affect scores (Supplemental Table 2). An age

345   difference could indicate differences in family relationships between FCs and

346   CRs; therefore, it is necessary to adjust for this factor in this study model in the

347   future. Fourth, our study investigated only TST and total time in bed, but FCs did

348   not rest only during sleep. No other sleep parameters could be collected in this

349   study because ActiGraph cannot measure sleep quality, as opposed to

350   polysomnography; therefore, simply stating that FCs who work should sleep at

351   night may not be enough for them to actually rest. Further study is needed to

352   investigate not only objective sleep parameters but also how rest and use of care

353   services can reduce care burden and negative affect. Finally, it is necessary to

354   consider nighttime behavioral and psychological symptoms of dementia (BPSD)

355   for CRs, because CRs' BPSD would likely be the most distressing for FCs.[4,30]

356   Previous studies have taken dementia into consideration to analyze the

357 association between care burden and sleep for FCs, whereas this study did

358 not.[3,5,6,8,13,14] Although approximately half of the CRs in the current study were

359 diagnosed with dementia, and it collected data on care levels of CRs that

360 considered the severity and symptoms of dementia according to the criteria of the

361 public long-term care insurance policy, it is necessary to assess the severity of

362 dementia and nighttime needs of CRs in future research.

363   In conclusion, a reduction in TST could lead to increased care burden and

364 more severe negative affect the following day for FCs, which may be moderated

365 by employment status. For FCs and CRs to continue living at home, it is important

366 to provide formal and informal support that takes into account nighttime sleep

367 status and employment status of FCs.

368

384

Conflict of Interest

386 None.

387

Description of Authors' Roles

389 H. Ryuno designed the study, collected the data, analyzed the data, and wrote

390 the paper. C. Greiner and Y. Yamaguchi helped design the study, supervised

391 data analysis, and assisted with writing the article.

392

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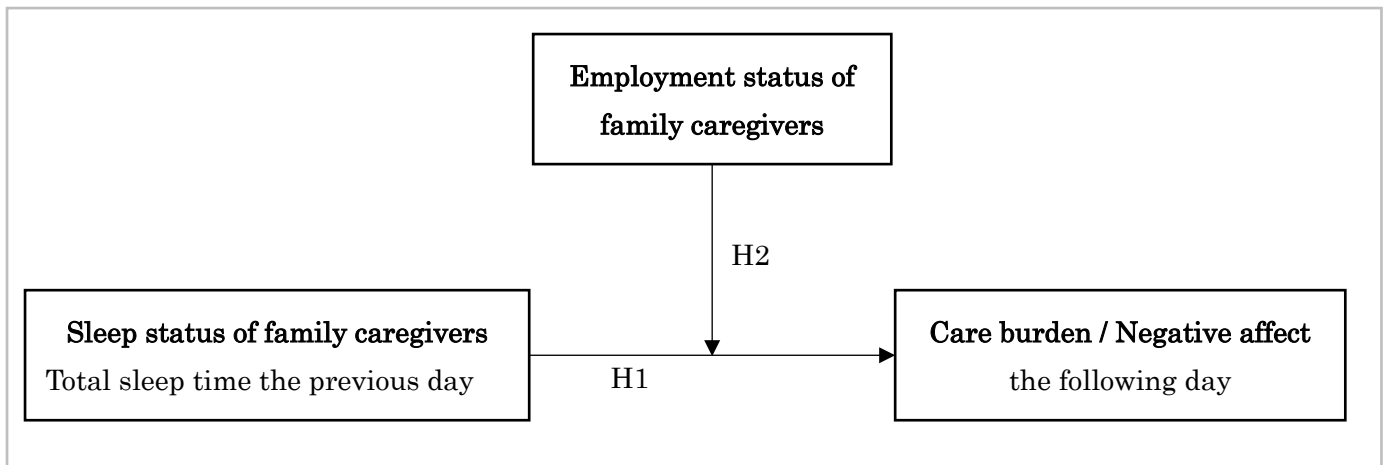
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Figure 1. Hypothesized model of factors influencing care burden and negative affect the following day among family caregivers who are employed or unemployed.
H1, hypothesis 1; H2, hypothesis 2.

Table 1. Participant Characteristics According to Caregiver's Employment Status

	Overall (n=25)	Employed (n=8)	Unemployed (n=17)	*P*-value
Family caregivers				
Age (years)	66.3 ± 10.8	56.9 ± 8.1	70.7 ± 9.1	**<.01**
Sex (female)	72.0	87.5	64.7	0.24
Relationship to care receiver				**<.01**
Spouse	44.0	0.0	64.7	
Son/daughter (in law)	56.0	100.0	35.3	
Hours of working per day (hours)	5.2 ± 1.9	5.2 ± 1.9	-	
Days of working per week (days)	3.6 ± 1.0	3.6 ± 1.0	-	
Duration of current work (years)	9.3 ± 5.9	9.3 ± 5.9	-	
ZBI_8 (/32)	7.3 ± 6.8	10.9 ± 7.3	5.8 ± 5.9	**<.001**
Positive affect (/50)	19.8 ± 8.4	20.5 ± 8.9	19.4 ± 8.1	0.18
Negative affect (/50)	16.1 ± 6.4	17.3 ± 7.5	15.5 ± 5.8	0.62
GDS-15 (/15)	4.3 ± 3.5	4.6 ± 4.4	4.2 ± 3.1	0.78
GDS-15≥5	41.6	37.5	43.8	0.77
WHO-5 Well-Being Index (/25)	13.8 ± 3.5	14.0 ± 3.5	12.9 ± 3.8	0.48
Total sleep time (hours)	5.7 ± 1.4	5.1 ± 1.5	6.0 ± 1.2	**<.01**
Total time in bed (hours)	6.6 ± 1.5	5.9 ± 1.6	6.8 ± 1.2	**<.01**
Sleep efficiency (%)	87.0 ± 7.8	88.7 ± 6.3	89.0 ± 4.9	0.90
Wake after sleep onset (min)	50.6 ± 32.5	41.4 ± 27.1	45.4 ± 18.6	0.67
PSQI (/21)	5.4 ± 3.6	5.9 ± 2.9	5.1 ± 3.9	0.63
PSQI≥5	36.0	37.5	35.3	0.92
Care receivers				
Age (years)	82.8 ± 8.2	87.0 ± 6.9	80.8 ± 8.2	0.08
Sex (female)	72.0	75.0	70.6	0.82
Care level [†]	2.7 ± 1.4	2.4 ± 1.6	2.8 ± 2.8	0.63
Age of care service use onset (years)	77.7 ± 8.9	82.4 ± 6.0	75.8 ± 9.3	0.10
Duration of care service use (years)	5.0 ± 4.0	5.0 ± 2.9	5.1 ± 4.4	0.98
Dementia	64.0	75.0	58.8	0.66
Moving assistance				0.08
Bedridden	24.0	0.0	35.3	
Wheel chair	36.0	62.5	23.5	
Ambulatory	40.0	37.5	41.2	
Bathing assistance	76.0	76.5	75.0	0.94
Eating assistance	60.0	75.0	52.9	0.29
Toileting assistance	80.0	87.5	76.5	0.52
GDS-15 (/15)	4.7 ± 3.5	4.0 ± 2.8	5.1 ± 4.0	0.08
GDS-15≥5	55.6	66.7	50.0	0.50

WHO-5 Well-Being Index (/25)	15.1 ± 4.5	16.1 ± 4.3	14.4 ± 4.7	0.43
PSQI (/21)	5.2 ± 2.7	4.3 ± 6.6	4.6 ± 3.1	0.91
PSQI≥5	38.9	20.0	36.4	0.63

Values are given as mean ± standard deviation or percentages, and they are calculated after excluding those with missing data. *P*-values for differences between employed and unemployed family caregivers were obtained from Mann-Whitney U-tests for continuous variables and Fisher's exact tests for dichotomous variables. Bold entries indicate significant values.

[†] Care levels were determined by assessing applicants' physical and mental status. Assistance required represents five levels, ranging from lowest (care level 1) to highest (care level 5) needs.

Abbreviations: ZBI_8, Short version of the Zarit Caregiver Burden Interview; WHO-5, World Health Organization-Five; GDS-15, Geriatric Depression Scale 15; PSQI, Pittsburgh Sleep Quality Index.

Table 2. Mixed Models on Caregiver Burden, Positive Affect, and Negative Affect

Dependent variable	ZBI_8		Negative affect		Positive affect	
Independent variable	Estimate	SE	Estimate	SE	Estimate	SE
Fixed effect						
Intercept	12.30***	2.20	15.98***	2.65	20.13***	3.45
Slope	-0.41*	0.17	-1.30***	0.36	-0.18	0.41
Unemployment – intercept	-5.68*	2.67	0.25	3.46	0.76	3.55
Unemployment – slope	0.35	0.22	1.45**	0.45	-0.10	0.52
Random effect						
Level 1 (Residual variance)	38.17***	11.36	30.15**	9.64	63.70**	20.15
Level 2 (Residual covariance)	6.93**	0.39	16.23***	1.13	20.39***	1.43

*$P<.05$ **$P<.01$ ***$P<.001$

This model predicts scores of ZBI_8, positive affect, and negative affect. Slopes indicate the rate of change for 1 hour of total sleep time. Total sleep time was centered by overall mean of total sleep time. Employment indicates family caregiver who worked a full- or part-time job during the day. A dummy variable was based on employment status and showed the rate of change for family caregivers who were not employed. Estimate indicated as a non-standardized coefficient.

Abbreviations: SE, standard error; ZBI_8, Short version of the Zarit Caregiver Burden Interview.
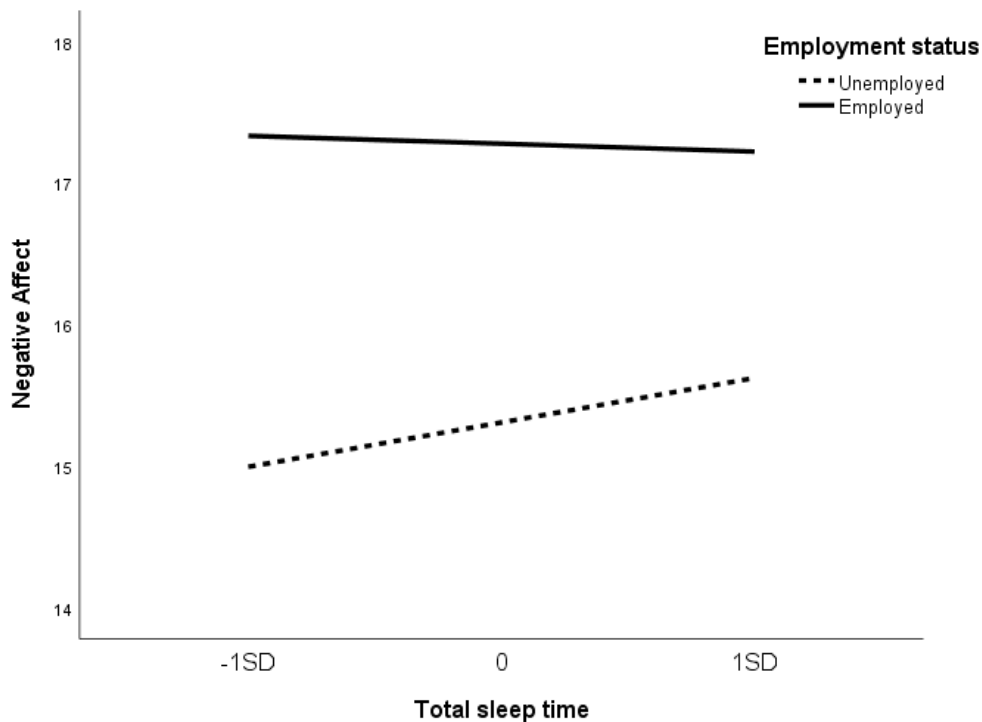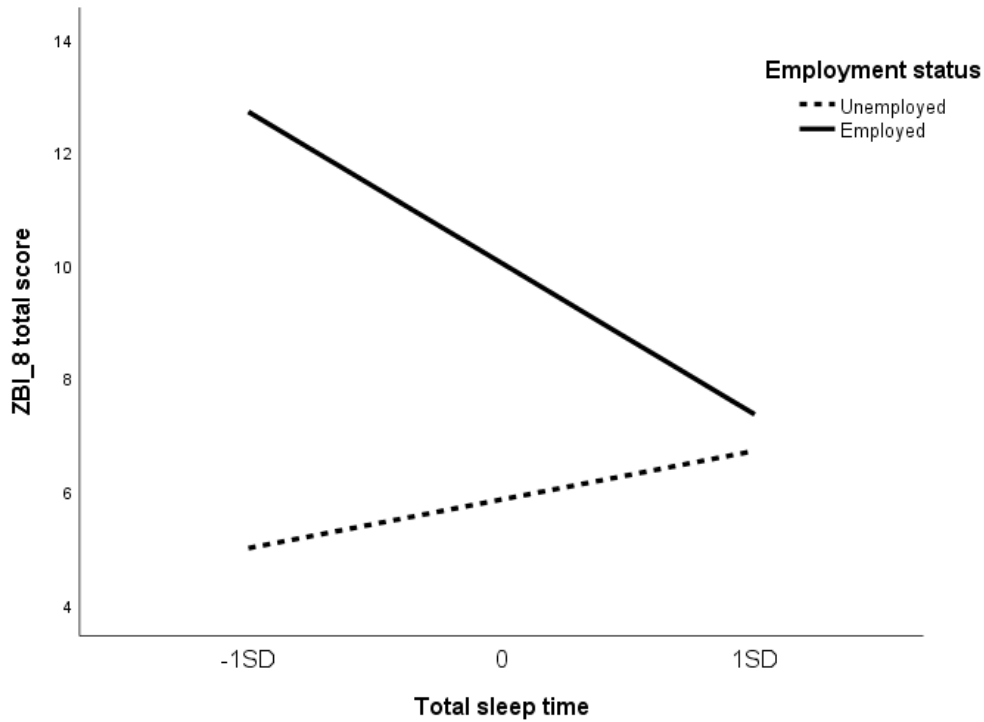
Figure 2. Model-predicted change of care burden (top) and negative affect (bottom) in terms of total sleep time. Average regression lines for employed (solid line) and unemployed (dotted line) groups. Total sleep time was centered by the mean of each group before being standardized. Slopes indicate the rate of change for 1 SD of total sleep time. Abbreviations: SD, standard deviation; ZBI_8, Short version of the Zarit Caregiver Burden Interview.

Supplemental Table 1. Correlation between Objective and Subjective Sleep Parameters, Care Burden, and Positive and Negative Affect (n=25)

	1	2	3	4	5	6
1. Total sleep time	-	0.938**	-0.358	-0.249	-0.081	-0.074
2. Total time in bed		-	-0.283	-0.260	-0.110	-0.042
3. PSQI			-	0.503*	-0.093	0.090
4. ZBI_8				-	0.169	0.382
5. Positive affect					-	-0.791**
6. Negative affect						-

*$P<.05$ **$P<.01$

Spearman's rank correlation analysis was performed between objective and subjective sleep parameters, care burden, and positive and negative affect.

Abbreviations: PSQI, Pittsburgh Sleep Quality Index; ZBI_8, Short version of the Zarit Caregiver Burden Interview.

Supplemental Table 2. Mixed Models on Caregiver Burden, Positive Affect, and Negative Affect According to Age Difference of FCs

Dependent variable	ZBI_8		Negative affect		Positive affect	
Independent variable	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Fixed effect						
Intercept	9.77***	2.05	5.47**	1.80	9.17***	2.61
Slope	0.12	0.17	0.01	0.33	-0.68	0.38
Elderly – intercept	-1.79	2.74	1.55	2.29	2.10	3.33
Elderly – slope	-0.72**	0.22	-0.15	0.44	0.60	0.51
Random effect						
Level 1 (Residual variance)	45.87**	13.65	27.30**	8.69	58.49**	18.59
Level 2 (Residual covariance)	6.87***	0.38	15.98***	1.08	20.81***	1.41

*P<.05 **P<.01 ***P<.001

This model predicts scores of ZBI_8, positive affect, and negative affect. Slopes indicate the rate of change for 1 hour of total sleep time. Total sleep time was centered by overall mean of total sleep time. Elderly indicates family caregiver who is above 65 years old. A dummy variable was based on elderly and showed the rate of change for family caregivers who were above 65 years old. Estimate indicated as a non-standardized coefficient.

Abbreviations: SE, standard error; ZBI_8, Short version of the Zarit Caregiver Burden Interview.