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# Associations of self-reported and objectively measured sleep disturbances with depression among primary caregivers of children with disabilities

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**Objective:** The objective of this study was to determine the association between sleep and depression using both self-reported (subjective) and actigraphic (objective) sleep traits.

**Methods:** A cross-sectional study was conducted among 175 female primary caregivers of children with disabilities receiving care at a rehabilitation center in Punta Arenas, Chile. The eight-item Patient Health Questionnaire was used to ascertain participants' depression status. The Pittsburgh Sleep Quality Index was used to define subjective, or perceived, sleep quality. Wrist-worn actigraph monitors, worn for seven consecutive nights, were used to characterize objective sleep quality and disturbances. Interviewer-administered questionnaires were used to collect information on sociodemographic and lifestyle factors. Linear regression models were fit using continuous sleep parameters as the dependent variables and depression status as the independent variable. Multivariable models were adjusted for body mass index, marital status, smoking status, education level, and children's disabilities.

**Results:** Using an eight-item Patient Health Questionnaire score  $\geq 10$ , 26.3% of participants presented with depression. Depressed women were more likely to self-report overall poorer (subjective) sleep compared to non-depressed women; however, differences in sleep were not consistently noted using actigraphic (objective) sleep traits. Among the depressed, both sleep duration and total time in bed were significantly underestimated. In multivariable models, depression was negatively associated with sleep duration using both subjective ( $\beta = -0.71$ , standard error [SE] = 0.25;  $P = 0.006$ ) and objective sleep ( $\beta = -0.42$ , SE = 0.19;  $P = 0.026$ ).

**Conclusion:** The association between sleep and depression differed comparing subjective and objective methods of assessment. Research strategies allowing for the integration of both perceived and objective measures of sleep traits are encouraged.

**Keywords:** actigraphy, caregiver, Chile, depression, Pittsburgh Sleep Quality Index, sleep

## Introduction

Poor sleep is ubiquitous, compromising alertness and psychological health. The international prevalence of poor sleep is estimated to range from 17% to 26%<sup>1-3</sup> and is associated with depression using different study designs and populations.<sup>1,3-7</sup> However, the method of sleep assessment varies among depression studies. Subjective sleep parameters rely on retrospective self-reports using questionnaires and surveys. One example of a subjective sleep instrument is the Pittsburgh Sleep Quality Index (PSQI).<sup>8</sup> Rather than self-reports, objective sleep parameters rely on monitoring of sleep-wake activity using electronic instrumentation. One example of an objective

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sleep instrument is wrist actigraphy, which estimates sleep–wake activity based on motor activity.<sup>9</sup> A number of studies have shown that results from subjective and objective sleep measures differ. These studies have included healthy men and women,<sup>10,11</sup> the depressed,<sup>12–14</sup> pregnant women,<sup>15,16</sup> women with severe premenstrual syndrome,<sup>17</sup> the elderly,<sup>18</sup> and caregivers.<sup>19</sup> Understanding the differences between subjective and objective sleep measures among caregivers is important because these populations are often at high risk for poor sleep and other comorbidities, which can have deleterious consequences on both the caregiver and care recipient.<sup>20–24</sup>

Caregivers report poorer sleep outcomes, greater anxiety, and greater depression when compared to noncaregivers,<sup>19,25–28</sup> and caregiver focus groups report that poor sleep has had negative impacts on health.<sup>20,29</sup> Caregivers of children with chronic health conditions show greater depressive symptoms compared to caregivers of children without chronic health conditions.<sup>26</sup> In addition, a graded relationship between caregiving burden and depression was observed when comparing caregivers of children with both neurodevelopmental and behavioral disorders to caregivers of children with either one or none of these disorders.<sup>30</sup> Therefore, we determined whether self-reported (subjective) sleep and wrist actigraphy (objective) sleep traits were each associated with depression and investigated the extent to which these associations differed among a sample of female caregivers of children with disabilities.

## Methods

### Study participants

The Chile Pediatric and Adult Sleep Study (CPASS) is a cross-sectional study conducted at the Centro de Rehabilitación Club de Leones Cruz del Sur in Punta Arenas, Chile that was designed to investigate the relationship between the sleep quality of children with disabilities and that of their primary caregivers with cardiometabolic and psychological health. This study was conducted among female primary caregivers of children with disabilities enrolled between September 2012 and July 2013 in two waves. The first wave (CPASS I) was conducted between September 2012 and December 2012 among caregivers of children aged 6–12 years receiving routine clinical care for disabilities at the center. The second wave (CPASS II) was conducted between April 2013 and July 2013 among caregivers of children with disabilities aged 10–21 years at the center. Both CPASS-I and CPASS-II study protocols have been described in further detail elsewhere.<sup>31,32</sup> The primary caregiver was defined as an adult for whom the child's well-being was her principal responsibility. Primary

caregivers included mothers, grandmothers, and relatives who were not diagnosed with developmental or intellectual disabilities. Research personnel invited 239 women, and from this group, 175 agreed to participate (73.2%), each in the care of one child.

### Study procedures

After obtaining written informed consent, a research psychologist administered structured questionnaires to women in order to collect information on sociodemographic and lifestyle factors and sleep characteristics. Following the structured interview, research staff instructed women to wear ActiSleep monitors (ActiLife; ActiGraph R&D, Pensacola, FL, USA) on nondominant wrists for seven consecutive nights. Although monitors were waterproof, women were instructed to remove them before showering and swimming.

### Data collection instruments and covariates

#### Pittsburgh Sleep Quality Index (PSQI)

Subjective sleep quality was assessed using PSQI, which measures sleep quality retrospectively over a 1-month period. The PSQI is a validated instrument for sleep research<sup>8,33</sup> and consists of 24 questions that generate seven component scores, each with a scale of 0–3; higher scores indicate poorer sleep outcomes. Component scores were then totaled for a global PSQI score ranging from 0 to 21, with higher scores indicating worse overall sleep quality. A global PSQI score >5 has been shown to yield a sensitivity of 89.6% and a specificity of 86.5% in distinguishing good (score ≤5) and poor sleepers (score >5).<sup>8</sup> Our analysis explored the following PSQI component scores: total time in bed (hours), sleep latency (minutes), sleep duration (hours), and sleep efficiency (%).

#### Wrist actigraphy

Objective sleep quality and disturbance were assessed with wrist actigraphy, an activity-based monitor to assess sleep–wake patterns, which has been shown to be valid in healthy and sleep-disordered populations.<sup>34–37</sup> Actigraphy data were collected using ActiSleep wrist-monitors that utilized ActiLife 6 data analysis software. Actigraphy-measured sleep data were collected in 1-minute epochs using the zero-crossing modes and the Cole-Kripke algorithm.<sup>9</sup> Caregivers wore ActiSleep monitors for seven consecutive nights on nondominant wrists. Reported actigraphy-measured parameters include total time in bed (hours), sleep latency (minutes),

sleep duration (hours), sleep efficiency (%), wake after sleep onset (WASO; minutes); average awakening length (minutes), and number of awakenings. Actigraphy wrist-monitors were inspected and cleaned prior to distribution to ensure that devices were in working condition, and visual inspection of data was performed regularly.

### Patient Health Questionnaire

Depression was assessed using the eight-item Patient Health Questionnaire (PHQ-8), which uses a self-administered module for unipolar depression that asks the participant “Over the last 2 weeks, how often have you been bothered by the following problems?” We did not include the ninth question from the nine-item Patient Health Questionnaire, which assesses for suicidal thoughts, because of the impracticality of timely clinical follow-up of positive responses. Also, in other studies, the modification of the nine-item Patient Health Questionnaire to the PHQ-8 depression questionnaire has been demonstrated to minimally influence overall scale performance, mean scores, or diagnostic cut points.<sup>38,39</sup> The eight items of the PHQ-8 include feigned interest, hopelessness, trouble sleeping, lack of energy, changes in appetite, self-deprecation, trouble concentrating, and changes in physical behavior. The participant’s endorsement of each item was ranked on a scale from 0 to 3: not at all (0), several days (1), more than half of the days (2), and nearly every day (3). Response to each item was summed for a total PHQ-8 score ranging from 0 to 24. Validated cutoffs were used to categorize patients into either depressed (PHQ-8 score  $\geq 10$ ) or non-depressed (PHQ-8 score  $< 10$ ) categories for comparison.<sup>38</sup> Using the *Diagnostic Statistical Manual*, fourth edition, a score  $\geq 10$  has been shown to be associated with 88% sensitivity and 88% specificity in diagnosing major depressive disorder<sup>38</sup> and validated for use in Spanish-speaking populations.<sup>40,41</sup>

### Covariates

Structured interviewer-administered questionnaires collected data on caregivers’ age, body mass index (BMI), ethnicity, marital status, current smoking status, alcohol consumption, employment status, and education level. BMI was calculated from the caregivers’ weight measured to the nearest 0.1 kg, and height was measured with a telescopic height instrument to the nearest 0.1 cm. According to the International Classification of Diseases, tenth revision,<sup>42</sup> children’s disabilities were grouped as follows: 1) mental and behavioral disorders (eg, autism); 2) diseases of the musculoskeletal system and connective tissue, skin, and subcutaneous system

(eg, scoliosis); 3) diseases of the nervous system (eg, cerebral palsy); and 4) congenital malformations and chromosomal abnormalities (eg, Down syndrome). Electronic medical records were reviewed to confirm children’s diagnoses.

### Statistical analysis

The Fisher’s exact and chi-square tests were used to evaluate differences in sociodemographic and lifestyle characteristics by caregiver depression status (PHQ-8 score of  $\geq 10$  vs PHQ-8 score  $< 10$ ). Differences in sleep between depressed women and nondepressed women were analyzed for both subjective and objective sleep parameters using either Student’s *t*-test or Kruskal–Wallis test. Among depressed and non-depressed groups, overlapping objective and subjective sleep parameters were compared using either paired *t*-tests or signed tests for matched pairs. Continuous nonparametric sleep variables were log transformed for regression analysis. Linear regression models were fit for each dependent sleep parameter. Depression and other covariates were independent variables. Multivariable models were adjusted for BMI (continuous), marital status (married or living with a partner vs divorced/separated/widowed/never married), current smoking status (yes or no), education level ( $<$ high school, high school, or  $>$ high school), and children’s disability group (mental and behavioral disorders, diseases of musculoskeletal system and connective/skin tissue, diseases of the nervous system, or congenital malformations and chromosomal abnormalities). A sensitivity analysis excluding the “trouble sleeping” item from the PHQ-8 was performed for the association between subjective sleep and depression. Statistical significance levels were set at a *P*-value  $< 0.05$  for two-sided analysis, and where appropriate, SDs, regression coefficients, and standard errors (SEs) were reported. All statistical analyses were performed using SAS<sup>®</sup> Version 9.3 (SAS Institute Inc., Cary, NC, USA).

### Ethical consideration

This study was approved by the institutional review boards of the Harvard T.H. Chan School of Public Health and the Centro de Rehabilitación Club de Leones Cruz del Sur in Punta Arenas, Chile. Written informed consent was obtained from all participants.

### Results

Our sample consisted of 175 female primary caregivers with a mean age of 40.6 years (SD = 8.7). Sociodemographic characteristics of study participants are summarized in Table 1. Using a PHQ-8 score  $\geq 10$ , 26.3% of participants presented

**Table 1** Sociodemographic characteristics of 175 female caregivers of children with disabilities, by depression status

	Total (n=175)	Depressed women (n=46)	Nondepressed women (n=129)	P-value <sup>a</sup>
Age (years), mean (SD)	40.6 (8.7)	40.6 (7.9)	40.6 (8.9)	0.989
Hispanic, n (%)	82 (46.9)	21 (45.7)	61 (47.3)	0.849
Marital status, n (%)				
Married or living with a partner	116 (66.3)	23 (50.0)	93 (72.1)	<b>0.007</b>
Divorced/separated/widowed/never married	59 (33.7)	23 (50.0)	36 (27.9)	
BMI (kg/m <sup>2</sup> ), mean (SD)	29.6 (5.6)	31.0 (6.3)	29.0 (5.3)	<b>0.037</b>
Current smoker, n (%)	82 (46.9)	29 (63.0)	53 (41.1)	<b>0.010</b>
Alcohol consumption, n (%)	30 (17.1)	5 (10.9)	25 (19.4)	0.189
Unemployed/student, n (%)	79 (45.1)	22 (47.8)	57 (44.2)	0.670
Education level, n (%)				
<High school	60 (34.3)	23 (50.0)	37 (28.7)	<b>0.013</b>
High school	59 (33.7)	15 (32.6)	44 (34.1)	
>High school	56 (32.0)	8 (17.4)	48 (37.2)	
Child disability group, n (%)				
Mental and behavioral disorders	75 (42.9)	17 (37.0)	58 (45.0)	0.713
Diseases of musculoskeletal system and connective/skin tissue	32 (18.3)	8 (17.4)	24 (18.6)	
Diseases of the nervous system	47 (26.9)	14 (30.4)	33 (25.6)	
Congenital malformations and chromosomal abnormalities	21 (12.0)	7 (15.2)	14 (10.9)	

**Notes:** Depression was defined using the PHQ-8 score  $\geq 10$ . <sup>a</sup>Student's t-test was conducted for age and BMI; chi-square test was conducted for other sociodemographic characteristics (categorical variables). P-values less than 0.05 are shown in bold.

**Abbreviations:** BMI, body mass index; PHQ-8, eight-item Patient Health Questionnaire.

with depression. When compared with nondepressed women, depressed women had higher mean BMI (31.0 kg/m<sup>2</sup> vs 29.0 kg/m<sup>2</sup>;  $P=0.037$ ), were less likely to report being married or living with a partner (50.0% vs 72.1%;  $P=0.007$ ), were more likely to report being a current smoker (63.0% vs 41.1%;  $P=0.010$ ), and were less likely to report a completed education beyond high school (17.4% vs 37.2%;  $P=0.013$ ). The majority of women cared for children with mental and behavioral disorders (42.9%), followed by children with nervous tissue diseases (26.9%), musculoskeletal and connective tissue diseases (18.3%), and congenital and chromosomal abnormalities (12.0%). However, the children's disability group did not statistically differ by caregivers' depression status ( $P=0.713$ ). Other characteristics, including age, ethnicity, alcohol consumption, and employment status, did not statistically differ by depression status.

Table 2 shows differences in subjective and objective sleep parameters comparing depressed and nondepressed women as well as univariate and multivariable regression coefficients for the association between sleep and depression. Compared with nondepressed women, depressed women self-reported shorter total time in bed (6.6 hours vs 7.3 hours;  $P=0.014$ ), longer sleep latency (60.0 minutes vs 20.0 minutes;  $P<0.001$ ), shorter sleep duration (5.8 hours vs 6.6 hours;  $P=0.001$ ), and poorer overall sleep quality using the median global PSQI score (11.0 vs 6.0;  $P<0.001$ ). No statistically significant differences were observed using subjective sleep

efficiency (88.2% vs 91.7%;  $P=0.570$ ). Similar to subjective sleep duration, objective sleep duration differed comparing depressed and nondepressed women (6.4 hours vs 6.9 hours;  $P=0.005$ ). Depressed women did not statistically differ from non-depressed women based on objective total time in bed (7.7 hours vs 8.1 hours;  $P=0.076$ ), objective sleep latency (7.2 minutes vs 11.1 minutes;  $P=0.453$ ), objective sleep efficiency (86.2% vs 87.2%;  $P=0.191$ ), objective WASO (54.6 minutes vs 50.9 minutes;  $P=0.361$ ), objective number of awakenings (14.4 vs 13.6;  $P=0.565$ ), and objective average awakening length (4.7 minutes vs 4.7 minutes;  $P=0.921$ ).

Table 2 also shows differences between subjective and objective sleep parameters within depression status groups. Among the depressed group, the mean subjective total time in bed (6.6 hours) was lower than the mean objective total time in bed (7.7 hours) and the difference statistically significant ( $-1.1$  hours, 95% Confidence Interval [CI]:  $-1.5$  to  $-0.7$ ;  $P<0.001$ ). Among the nondepressed, the mean subjective total time in bed (7.3 hours) was lower than the mean objective total time in bed (8.1 hours) and the difference statistically significant ( $-0.8$  hours, 95% CI:  $-1.1$  to  $-0.5$ ;  $P<0.001$ ). Among the depressed group, the mean subjective sleep duration (5.8 hours) was lower than the mean objective sleep duration (6.4 hours) and the difference statistically significant ( $-0.6$  hours, 95% CI:  $-1.0$  to  $-0.2$ ;  $P=0.005$ ). Among the nondepressed, the mean subjective sleep duration (6.6 hours) was lower than the mean objective sleep duration

**Table 2** Differences in subjective and objective-measured sleep parameters between depressed and non-depressed women

Dependent variables	Depressed (n=46)	Nondepressed (n=129)	P-value <sup>a</sup>	Univariate models		Multivariable models <sup>b</sup>	
				$\beta$ (SE)	P-value	$\beta$ (SE)	P-value
Subjective: PSQI-reported sleep parameters							
Total time in bed (hours), mean (SD)	6.6 (1.5)	7.3 (1.6)	<b>0.014</b>	-0.67 (0.27)	<b>0.014</b>	-0.61 (0.29)	<b>0.033</b>
Sleep latency (minutes), median (interquartile) <sup>c</sup>	60.0 (30.0, 90.0)	20.0 (10.0, 60.0)	< <b>0.001</b>	0.72 (0.19)	< <b>0.001</b>	0.58 (0.20)	<b>0.003</b>
Sleep duration (hours), mean (SD)	5.8 (1.3)	6.6 (1.4)	<b>0.001</b>	-0.81 (0.24)	<b>0.001</b>	-0.71 (0.25)	<b>0.006</b>
Sleep efficiency (%), median (interquartile) <sup>c</sup>	88.2 (77.4, 100.0)	91.7 (80.0, 100.0)	0.570	-0.02 (0.03)	0.540	-0.01 (0.03)	0.743
Global PSQI score, median (interquartile) <sup>c</sup>	11.0 (9.0, 13.0)	6.0 (4.0, 9.0)	< <b>0.001</b>	0.56 (0.08)	< <b>0.001</b>	0.53 (0.08)	< <b>0.001</b>
Objective: actigraphy-measured sleep parameters <sup>d</sup>							
Total time in bed (hours), mean (SD)	7.7 (1.3)	8.1 (1.3)	0.076	-0.40 (0.22)	0.076	-0.32 (0.23)	0.174
Sleep latency (minutes), median (interquartile) <sup>c</sup>	7.2 (2.9, 17.1)	11.1 (4.7, 18.9)	0.453	-0.15 (0.23)	0.513	-0.19 (0.23)	0.408
Sleep duration (hours), mean (SD)	6.4 (0.9)	6.9 (1.0)	<b>0.005</b>	-0.51 (0.18)	<b>0.005</b>	-0.42 (0.19)	<b>0.026</b>
Sleep efficiency (%), median (interquartile) <sup>c</sup>	86.2 (80.0, 88.9)	87.2 (81.6, 90.0)	0.191	-0.02 (0.01)	0.123	-0.02 (0.01)	0.210
WASO (minutes), median (interquartile)	54.6 (42.1, 75.2)	50.9 (35.4, 75.6)	0.361	0.09 (0.10)	0.339	0.11 (0.10)	0.274
Average awakening length (minutes), median (interquartile) <sup>c</sup>	4.7 (3.2, 7.2)	4.7 (3.5, 6.6)	0.921	-0.002 (0.09)	0.985	-0.06 (0.09)	0.531
Number of awakenings, median (interquartile) <sup>c</sup>	14.4 (11.6, 18.4)	13.6 (10.4, 17.7)	0.565	0.03 (0.08)	0.701	0.08 (0.08)	0.366

**Notes:** Depression was defined using the PHQ-8 score  $\geq 10$ . <sup>a</sup>Student's t-tests were conducted for parametric variables with mean, and Kruskal-Wallis tests were conducted for nonparametric variables with median. <sup>b</sup>Models were adjusted for women's body mass index (continuous), marital status, current smoking status, education level, and children's disability group. <sup>c</sup>Log transformation was made for nonparametric variables in the linear regression models. <sup>d</sup>For actigraphy-measured sleep parameters, the number of depressed women was 44, while the number of nondepressed women was 127. P-values less than 0.05 are shown in bold.

**Abbreviations:** SE, standard error; PSQI, Pittsburgh Sleep Quality Index; WASO, wake after sleep onset; PHQ-8, eight-item Patient Health Questionnaire.

(6.9 hours); however, the difference was not statistically significant (-0.3 hours, 95% CI: -0.54 to 0.01;  $P=0.059$ ). Among the depressed, the median subjective sleep latency (60.0 minutes) was higher than the median objective sleep latency (7.2 minutes) and difference statistically significant ( $P<0.001$ ). Among the nondepressed, the median subjective sleep latency (20.0 minutes) was higher than the median objective sleep latency (11.1 minutes) and the difference statistically significant ( $P<0.001$ ). Among the depressed group, the median subjective sleep efficiency (88.2%) was higher than the median objective sleep efficiency (86.2%); however, the difference was not statistically significant ( $P=0.451$ ). Among the nondepressed group, the median subjective sleep efficiency (91.7%) was higher than the median objective sleep efficiency (87.2%) and the difference was statistically significant ( $P=0.019$ ).

All multivariable models were adjusted for BMI (continuous), marital status, current smoking status, education level, and children's disability group. Subjective multivariable models show depression to be negatively associated with total time in bed ( $\beta=-0.61$ , SE =0.29;  $P=0.033$ ) and sleep duration ( $\beta=-0.71$ , SE =0.25;  $P=0.006$ ) and positively associated with subjective sleep latency ( $\beta=0.58$ , SE =0.20;  $P=0.003$ ) and subjective overall poor sleep quality using the global PSQI score ( $\beta=0.53$ , SE =0.08;  $P<0.001$ ). Depression was also negatively associated with objective sleep duration ( $\beta=-0.42$ , SE =0.19;  $P=0.026$ ). No statistically significant associations were found for subjective sleep efficiency

( $\beta=-0.01$ , SE =0.03;  $P=0.743$ ), objective total time in bed ( $\beta=-0.32$ , SE =0.23;  $P=0.174$ ), objective sleep latency ( $\beta=-0.19$ , SE =0.23;  $P=0.408$ ), objective sleep efficiency ( $\beta=-0.02$ , SE =0.01;  $P=0.210$ ), objective WASO ( $\beta=0.11$ , SE =0.10;  $P=0.274$ ), objective average awakening length ( $\beta=-0.06$ , SE =0.09;  $P=0.531$ ), and objective number of awakenings ( $\beta=0.08$ , SE =0.08;  $P=0.366$ ). Table 3 shows the results from the sensitivity analyses that excluded the "trouble sleeping" item from the PHQ-8. Results from the sensitivity analyses did not substantially change the subjective associations previously reported in Table 2. Notably, subjective sleep latency was no longer statistically significant in multivariable models ( $\beta=0.30$ , SE =0.22;  $P=0.184$ ). Changes in objective associations also did not substantially differ (data not shown).

## Discussion

Our study found an association between some sleep traits and depression and a difference in the extent of the association when comparing subjective and objective sleep measures. Our study also observed an overall underestimation of total time in bed and sleep duration, although only the underestimation among the depressed group was statistically significant. We also report a robust negative association between depression and sleep duration using both subjective and objective sleep measures, and that the magnitude of association was strongest using subjective sleep measures. In addition, we found that the prevalence of depression among caregivers

**Table 3** Differences in subjective sleep parameters between depressed and nondepressed women (PHQ-8 excluded item 3: trouble sleeping)

Dependent variables	Depressed (n=32)	Nondepressed (n=143)	P-value <sup>a</sup>	Univariate models		Multivariable models <sup>b</sup>	
				$\beta$ (SE)	P-value	$\beta$ (SE)	P-value
Subjective: PSQI-reported sleep parameters							
Total time in bed (hours), mean (SD)	6.3 (1.4)	7.3 (1.6)	<b>0.001</b>	-1.00 (0.30)	<b>0.001</b>	-0.98 (0.31)	<b>0.002</b>
Sleep latency (minutes), median (interquartile) <sup>c</sup>	52.5 (20.0, 75.0)	30.0 (10.0, 60.0)	<b>0.021</b>	0.45 (0.22)	<b>0.041</b>	0.30 (0.22)	0.184
Sleep duration (hours), mean (SD)	5.5 (1.2)	6.6 (1.4)	<b>&lt;0.001</b>	-1.12 (0.27)	<b>&lt;0.001</b>	-1.02 (0.27)	<b>&lt;0.001</b>
Sleep efficiency (%), median (interquartile) <sup>c</sup>	88.9 (78.7, 100.0)	91.7 (77.8, 100.0)	0.907	-0.02 (0.03)	0.497	-0.01 (0.03)	0.692
Global PSQI score, median (interquartile) <sup>c</sup>	11.5 (9.0, 14.0)	7.0 (5.0, 9.0)	<b>&lt;0.001</b>	0.52 (0.09)	<b>&lt;0.001</b>	0.47 (0.09)	<b>&lt;0.001</b>

**Notes:** Depression was defined using the PHQ-8 score  $\geq 10$ . <sup>a</sup>Student's t-tests were conducted for parametric variables with mean, and Kruskal-Wallis tests were conducted for nonparametric variables with median. <sup>b</sup>Models were adjusted for women's body mass index (continuous), marital status, current smoking status, education level, and children's disability group. <sup>c</sup>Log transformation was made for nonparametric variables in the linear regression models. P-values less than 0.05 are shown in bold.

**Abbreviations:** PHQ-8, eight-item Patient Health Questionnaire; SE, standard error; PSQI, Pittsburgh Sleep Quality Index.

in our study (26.3%) was within the range of depression estimates reported in other studies of caregivers for children with disabilities (15%–32%).<sup>30,43</sup>

Our finding of an association between some sleep traits and depression corroborates with the literature relating to this topic.<sup>1,3–7</sup> Our finding of differences comparing subjective and objective sleep measures is also supported by much of the literature,<sup>10–19</sup> despite limited findings to the contrary.<sup>44</sup> Among studies that have looked at such differences among the depressed patients, they have reported that depressed patients are more likely to poorly recall aspects of sleep compared to the nondepressed patients.<sup>12–14</sup> However, the direction of the inconsistency is mixed. For example, although we observed that depressed women significantly underreported sleep duration while nondepressed women did not, others have reported that depressed individuals may in fact be more likely to over report sleep duration.<sup>12</sup> Finally, our finding of differences in the association between sleep and depression comparing subjective and objective sleep measures has also been previously reported. For example, in a recent study of pregnant women with and without a confirmed mental disorder, daily reported (subjective) sleep variables showed significant associations with patient status in multivariable models, while wrist actigraphy (objective) sleep did not.<sup>16</sup>

Results from a recent meta-analysis reported that when compared to normal sleep duration, short sleep duration is significantly associated with depression in adults (relative risk = 1.31, 95% CI: 1.04 to 1.64).<sup>4</sup> In our study, a robust negative association between depression and sleep duration was found using both subjective and objective sleep measures. Similar associations between mental health outcomes and sleep duration have been observed in other studies of caregivers.<sup>19,25</sup> For example, in a sample of male and female caregivers, sleep duration was significantly associated with higher

levels of depression using the Hospital Anxiety and Depression Scale.<sup>25</sup> It is important to note that the association between sleep and depression is multifaceted and is impacted not only by changes in sleep features, such as shortened sleep duration, but also by changes in social and environmental factors.<sup>45,46</sup> Interestingly, in a study among young adult women, perceived stress was associated with poorer subjective sleep quality but not with actigraphic (objective) sleep measures.<sup>47</sup>

Although perceived (subjective) and actual (objective) sleep measures share commonalities, it is not surprising that the two differ. Buysse et al<sup>48</sup> and Vitiello et al<sup>49</sup> have previously demonstrated that individuals adapt perception of “acceptable” sleep. For example, in a study of healthy older individuals, although participants reported no perceptions of poor sleep using subjective sleep measures, objective sleep measures showed significant sleep disturbances.<sup>49</sup> In our case, the opposite may be occurring. Depressed individuals may have had altered perceptions of acceptable sleep in that they perceived and self-reported sleep disturbances, despite few observed differences from nondepressed individuals using objective sleep measures. It may also be the case that perception of sleep among individuals with a comorbid mood disorder is a function of cognition, severity of depression, and actual sleep, rather than actual sleep alone, as suggested in previous studies.<sup>13,14</sup> Furthermore, shorter sleep duration interferes with memory consolidation,<sup>50</sup> which may influence perception of sleep.<sup>51</sup> Perceptions of poor sleep may then go on to influence sleep-disruptive compensatory behaviors, such as increased anxiety during times of rest,<sup>52</sup> thereby perpetuating poor sleep among individuals who perceive that they sleep poorly.

Our study had several strengths including the use of validated sleep and depression instruments and analytical handling of potential confounders. Our study addressed

confounding in two ways. First, we excluded women who were diagnosed with developmental or intellectual disabilities. This exclusion criterion reduced the potential confounding influence that caregivers' disability status might have had on both sleep and depression. Second, we adjusted for covariates associated with sleep and depression in our study population in multivariable models. However, we could not discount the possibility of residual confounding. Additionally, a sensitivity analysis showed that the influence of the PHQ-8 sleep criteria "trouble sleeping" did not substantially influence the observed associations between subjective sleep and depression. Despite these strengths, our study had some limitations. Our relatively small sample size might have affected our power to detect an association between sleep and depression in some instances. Additionally, our study was cross-sectional and thus was unable to determine the temporal association between sleep and depression. We could not distinguish whether perception of acceptable sleep was influenced by depression or whether depression was influenced by perception of acceptable sleep. We were also limited in our ability to report on other comorbid features associated with caregiving, including anxiety and perceived stress. Furthermore, the generalizability of our findings may also be limited to our specific study population and setting.

## Conclusion

The health of caregivers is a twofold concern, in our case affecting both caregivers and children with disabilities. Rehabilitation providers for children with disabilities are well positioned to monitor the sleep and mental health of caregivers and provide the necessary resources, referrals, and interventions. Our study shows that the association between sleep and depression differs comparing subjective and objective methods of assessment and that short sleep duration is associated with depression using both subjective and objective sleep measures. Therefore, sleep intervention strategies for caregivers may benefit from a focus on sleep duration, and research strategies allowing for the integration of both perceived and objective measures of sleep traits are encouraged.

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## Disclosure

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