

BMJ Open

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID: | bmjopen-2015-008589 |
| Article Type: | Research |
| Date Submitted by the Author: | 24-Apr-2015 |
| Complete List of Authors: | Chen, Xiaoli; Harvard T.H. Chan School of Public Health, Department of Epidemiology Velez, Juan Carlos; Centro de Rehabilitación Club de Leones Cruz del Sur, Barbosa, Clarita; Centro de Rehabilitación Club de Leones Cruz del Sur, Pepper, Micah; Centro de Rehabilitación Club de Leones Cruz del Sur, Gelaye, Bizu; Harvard T.H. Chan School of Public Health, Department of Epidemiology Redline, Susan; Brigham and Women's Hospital, Division of Sleep and Circadian Disorders; Harvard Medical School, Department of Medicine Williams, Michelle; Harvard T.H. Chan School of Public Health, Department of Epidemiology |
| Primary Subject Heading: | Paediatrics |
| Secondary Subject Heading: | Public health, Epidemiology |
| Keywords: | SLEEP MEDICINE, Community child health < PAEDIATRICS, PUBLIC HEALTH |
| | |

SCHOLARONE™
Manuscripts

only

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities

Xiaoli Chen, MD, MPH, PhD*¹, Juan Carlos Velez, MD², Clarita Barbosa, MD², Micah Pepper, MPH², Bizu Gelaye, MPH, PhD¹, Susan Redline, MD, MPH^{1,3,4}, Michelle A. Williams, ScD¹

¹Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA 02115, USA

²Centro de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile

³Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston MA 02115

⁴Department of Medicine, Harvard Medical School, Boston, MA 02115, USA

***Address correspondence to:** Xiaoli Chen, MD, MPH, PhD, Department of Epidemiology, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, Phone: 617-432-0067, xchen@hsph.harvard.edu

SHORT TITLE: Sleep patterns among children with disabilities

Abstract: 257 words

Text: 3136 words

Tables: 4; Figures: 1

Supplementary table: 1

Supplementary figure: 1

KEY WORDS

Child, disability, caregiver, education, sleep parameter, actigraph, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

ABBREVIATIONS

ADHD-attention-deficit/hyperactivity disorder

ASD-autism spectrum disorder

CI-confidence interval

CPASS-Chile Pediatric and Adult Sleep and Stress Study

ICD-International Classification of Diseases

IQR-interquartile range

OR-odds ratio

SD-standard deviation

SE-standard error

WASO-wake after sleep onset

Abstract

Objectives: To characterize actigraphy-measured sleep patterns among children with disabilities and to examine whether caregivers' education is associated with sleep disturbances.

Design: Cross-sectional study.

Setting: A rehabilitation center in the Patagonia region, Chile.

Methods: This pilot study was conducted among 125 children aged 6-12 years with disabilities (boys: 55.2%) and caregivers in Chile. Children wore ActiSleep monitors for seven days. General linear models were fitted to generate least-square mean and standard error (SE) of sleep efficiency across caregivers' education levels adjusting for children's age, sex, disability type, caregiver-child relationship, and caregivers' age. Multivariable logistic regression analyses were conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of longer sleep latency (≥ 30 minutes) and longer wake after sleep onset (WASO) (≥ 90 minutes) (a measure of sleep fragmentation) in relation to caregivers' educational attainment.

Results: Median sleep latency was 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours. Mean sleep efficiency was 80.0%. Caregivers' education was positively and significantly associated with children's sleep efficiency ($P_{trend}=0.001$). Adjusted mean sleep efficiency was 75.7% (SE=1.4) among children of caregivers <high school, and 81.9% (SE=1.0) among children of caregiver >high school. Compared to children whose caregivers had >high school, children of caregivers with <high school had higher odds of longer sleep latency (OR=3.27; 95% CI=1.12-9.61) and longer WASO (OR=5.95; 95% CI=1.91-18.53). Associations were consistent across disability types.

1
2
3 **Conclusions:** Children with disabilities experience difficulties initiating sleep (prolonged sleep
4 latency) and maintaining sleep (long WASO, low sleep efficiency). Among children with
5 disabilities, lower caregiver education level is associated with more sleep disturbances.
6
7
8
9

10
11 **KEY WORDS:** child, disability, caregiver, education, sleep parameter, actigraph, sleep
12 duration, sleep efficiency, sleep latency, wake after sleep onset
13
14
15
16
17
18
19

20 **Strengths and limitations of this study**

- 21
22 ■ This pilot study is strengthened by its use of actigraphy which has been well validated for
23 objective estimation of nighttime sleep parameters in the natural sleep environment.
24
- 25
26 ■ Our study was unique in being the first study to examine the associations between
27 caregivers' education and actigraphy-measured sleep among children with disabilities.
28
- 29
30 ■ Its strength also lies in the statistical analysis that was performed using univariate and
31 multivariable linear and logistic regression models.
32
33
- 34
35 ■ This is a cross-sectional, pilot study with a small sample size and high heterogeneity of
36 disabilities included.
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

INTRODUCTION

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Approximately 150 million children live with disabilities worldwide.¹ Sleep disturbances, particularly difficulty initiating and maintaining sleep, are commonly reported among children with a wide range of disabilities including attention-deficit/hyperactivity disorder (ADHD) and autism.²⁻⁶ There are discrepancies between objective measures of sleep and those reported by parents of children with disabilities.⁵ Parents may be, unaware of children's sleep disturbances, such as night awakenings, and tend to overestimate their children's sleep duration.⁷ Inferences from prior studies are limited because investigators have relied on parental report of child sleep.³ Although polysomnography is considered the gold standard for measuring sleep, it is burdensome and not easily amenable for use with children who have difficulties sleeping in unfamiliar surroundings. Actigraphy-based sleep offers opportunities to obtain objective measures of sleep in children's typical environment. Actigraphy has been validated for objective measures of sleep in clinical- and population-based studies.^{8,9}

Sleep disturbances have been related to sociodemographic, environmental, and behavioral factors.¹⁰⁻¹³ Children's sleep disturbances have been connected with their home environment that may be influenced by caregivers' characteristics.^{13,14} Our recent qualitative study showed that while both caregivers and rehabilitation providers recognized the importance of sleep health, they differed in their understanding of how sleep practices influence sleep health.¹³ Parental ability to provide support for healthy behaviors including sleep may be influenced by parental education, a known factor associated with child health measures.^{12,15-17} Magana et al reported that maternal education and knowledge about autism accounted for differences in the number of specialty services received by Latino children with autism spectrum disorder (ASD) as compared

1
2
3 with White children in the US.¹⁵ However, to our knowledge, little research has been conducted
4
5 regarding the role of caregivers' education in objectively measured sleep among children with
6
7 disabilities.
8
9

10
11
12 This pilot study aimed to characterize actigraphy-measured sleep patterns and to examine
13
14 whether caregivers' education is associated with sleep disturbances among children with
15
16 disabilities. Our hypotheses include that actigraphy-measured sleep disturbances including long
17
18 sleep latency, long wake after sleep onset, short sleep, and poor sleep are common among
19
20 children with disabilities. Caregivers' low levels of educational attainment are strongly
21
22 associated with children's sleep disturbances. The use of actigraphy was intended to eliminate
23
24 the influence of reporting errors in sleep patterns of children with disabilities.
25
26
27
28
29
30

31 **METHODS**

32 **Participants**

33
34
35 The Chile Pediatric and Adult Sleep and Stress Study (CPASS) was a cross-sectional, pilot
36
37 study that was established in September 2012 at the Centro de Rehabilitacion Club de Leones
38
39 Cruz del Sur in Punta Arenas, Chile.¹³ The first wave of the CPASS (CPASS I) was conducted
40
41 between September and December in 2012 among children aged 6-12 years who were receiving
42
43 routine clinical care for disabilities (e.g., having impairments, activity limitations, participation
44
45 restrictions) due to health conditions such as autism, Down's Syndrome, cerebral palsy at the
46
47 center and their primary caregivers who were parents, grandparents, relatives, or other adults and
48
49 were principally responsible for children's wellbeing and did not have developmental or
50
51 intellectual disabilities. A total of 110 children and caregivers (one caregiver per child) were
52
53
54
55
56
57
58
59
60

1
2
3 recruited in the CPASS I. Five children were excluded from this study due to incomplete
4
5 actigraphy data: four children removed monitors after day one or day two of the study and/or
6
7 without sleep log data; one child lost the monitor on day two. A total of 105 child-caregiver
8
9 dyads (95.5% of enrolled families) completed the CPASS I study protocol. The second wave of
10
11 the CPASS (CPASS II) was conducted among children with disabilities aged 10-21 years and
12
13 their primary caregivers between April and July in 2013 at the center.^{18, 19} Research personnel
14
15 invited 129 caregivers of children with disabilities to participate. A total of 90 caregivers (72%)
16
17 agreed to participate in the study. Twenty children were aged 10-12 years from the CPASS II. In
18
19 total, 125 children aged 6-12 years were included in the study.
20
21
22
23
24
25
26

27 Written informed consents were obtained from primary caregivers of children with disabilities.

28
29 This study was approved by the institutional review boards of the Centro de Rehabilitacion Club
30
31 de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human
32
33 Research Administration.
34
35
36
37
38

39 **Study Procedures**

40
41 A psychologist administered structured questionnaires to caregivers to collect information on
42
43 sociodemographic and lifestyle factors of children and caregivers. Research staff instructed
44
45 children to wear ActiSleep monitors (ActiLife, ActiGraph R&D, Florida, USA)²⁰ on their non-
46
47 dominant wrists for seven consecutive days. Although the monitors are waterproof, children and
48
49 their caregivers were instructed to remove them from their wrists before taking showers and
50
51 before swimming. Caregivers were also instructed to keep sleep logs of time in bed and time out
52
53
54
55
56
57
58
59
60

1
2
3 of bed for their children. Electronic medical records were reviewed by a physician to confirm
4
5 children's disabilities defined by the World Health Organization.²¹
6
7

8 9 10 **Sleep Parameters**

11
12
13 Actigraphic sleep data were collected using the ActiSleep monitors and were analyzed using
14
15 the ActiLife 6 data analysis software.²⁰ When worn during sleep episodes, the ActiSleep monitor
16
17 can provide sleep measures including sleep onset, sleep latency, wake after sleep onset (WASO),
18
19 number and length of awakenings, sleep duration, and sleep efficiency. Sleep latency is the
20
21 length of time taken to fall asleep, calculated as the time of "lights off" to the first period of 3
22
23 minutes of consecutive epochs scored as sleep. WASO is the number of minutes awake between
24
25 sleep onset and time of final waking. Sleep efficiency is defined as the proportion of the
26
27 estimated sleep periods spent asleep. Actigraphy data were collected in 1-min epochs using the
28
29 zero-crossing modes, and the "Sadeh" sleep algorithm was used for children.²² The majority of
30
31 children (98.4%) had complete 7-day actigraphic sleep data; two children had 6-day actigraphic
32
33 data and one child had 3-day data available for study.
34
35
36
37
38
39
40
41

42 **Sociodemographic Characteristics and Child Disabilities**

43
44 Interviewer-administered questionnaires were used to collect information on children's age, sex,
45
46 caregiver-child relationship (e.g., mother), caregivers' age, and education levels. Caregivers were
47
48 asked to report the highest degree of education they had completed: less than 12th grade, high
49
50 school graduate or equivalent, some college degree, or college graduate or above. According to
51
52 the International Classification of Diseases (ICD-10),²³ children's disabilities were grouped as:
53
54 1) mental and behavioral disorders (e.g., autism, ADHD); 2) diseases of the musculoskeletal
55
56
57
58
59
60

1
2
3 system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); 3) diseases of the
4 nervous system (e.g., cerebral palsy); and 4) congenital malformations, deformations and
5 chromosomal abnormalities (e.g., Down syndrome).
6
7
8
9

10 11 12 **Statistical Analysis**

13 Kolmogorov-Smirnov test was used to assess the normality of sleep parameters. Variables were
14 described using means and standard deviations (SDs) for parametric variables and medians and
15 interquartile ranges (IQRs) for nonparametric variables. Student's t-test was used for age, sleep
16 efficiency, and number of awakening as parametric variables; Wilcoxon rank-sum test was used
17 to test differences in nonparametric variables including sleep onset, sleep latency, WASO,
18 awakening length, and sleep duration by child sex. Fisher's or χ^2 test was conducted to compare
19 differences in sociodemographic factors and disability groups by child sex. Analysis of variance
20 or Kruskal-Wallis test was conducted to evaluate differences in sleep parameters across
21 children's disability groups and caregivers' education levels.
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

39 General linear model was fitted to generate least-square mean and standard error (SE) of sleep
40 efficiency across caregivers' education levels with adjustment for children's age, sex, disability,
41 caregiver-child relationship, and caregivers' age. Univariate and multivariable linear regression
42 analyses were performed to examine the associations of caregivers' education level with sleep
43 efficiency and the number of awakenings. Stratified analysis was conducted to evaluate whether
44 associations between caregivers' education and children's sleep disturbances differed according
45 to disability groups. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using
46 logistic regression models to evaluate the associations of caregivers' educational attainment with
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 children's long sleep latency (≥ 30 vs. < 30 minutes), long WASO (≥ 90 vs. < 90 minutes), and
4
5 short sleep duration (< 8 vs. ≥ 8 hours). These cut points were chosen based on the literature of
6
7 sleep latency²⁴ and sleep duration,²⁵ as well as sleep data distributions in the study (WASO
8
9 median=88 minutes, sleep duration median=8 hours; only 9.6% of children had sleep ≥ 9 hours).
10
11 We also included a variable to represent study wave (I and II) in multivariable regression models
12
13 and found similar results (data not shown). Statistical significance levels were set at $P < 0.05$ for
14
15 two-sided analyses. All tests were performed using SAS 9.3 (SAS Institute, Cary, NC).
16
17
18
19
20
21

22 RESULTS

23
24 The mean age of children was 9.2 (SD=2.2) years. Most caregivers were mothers (88.0%);
25
26 21.6% of caregivers reported having <high school (**Table 1**). There were no statistically
27
28 significant differences in caregiver-child relationship, caregivers' age or education between boys
29
30 and girls.
31
32
33
34
35

36 Median time for sleep onset was 22:39, sleep latency 27.3 minutes, WASO 88.1 minutes, and
37
38 sleep duration 8.0 hours (**Table 1**). Mean number of awakening was 22.1, sleep efficiency
39
40 80.0%. There were no statistically significant differences in sleep parameters between boys and
41
42 girls (all $P > 0.05$). Overall, 43.2% of children had sleep latency ≥ 30 minutes, 51.2% had short
43
44 sleep < 8 hours, and 77.6% had low sleep efficiency $< 85\%$.
45
46
47
48
49

50
51 There were no significant differences in sleep parameters across disability groups
52
53 (**Supplementary Figure 1**), except for the number of nocturnal awakening (**Supplementary**
54
55 **Table 1**). Children with diseases of musculoskeletal system and connective tissue, skin and
56
57
58
59
60

1
2
3 subcutaneous tissue appeared to have more awakenings, reflecting more fragmented sleep, than
4
5 children with other disabilities.
6
7

8
9
10 Children whose caregivers had <high school had longer sleep latency, longer WASO, longer
11
12 awakening length, and lower sleep efficiency compared to children whose caregivers had >high
13
14 school (**Figure 1, Table 2**). Although children of caregivers with <high school tended to have
15
16 later sleep onset, higher number of awakenings, and shorter sleep duration when compared to
17
18 children of caregivers with higher education, these differences did not reach statistical
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
significance.

After adjustment for child age, sex, disability group, caregiver-child relationship, and caregiver
age, mean sleep efficiency was the lowest among children of caregivers with <high school
(75.7% [SE=1.4]), followed by children of caregivers with high school (80.4% [SE=1.0]) and
>high school (81.9% [SE=1.0]).

Linear regression analyses showed no significant associations between caregivers' education
levels and children's awakening number. However, compared to children whose caregivers had
>high school, children of caregivers with <high school had significantly lower sleep efficiency
(adjusted beta=-6.3, SE=1.7; P=0.001) (**Table 3**). Caregivers' educational attainment was
significantly and positively associated with children's sleep efficiency ($P_{trend}=0.001$).

As shown in **Table 4**, compared to children whose caregivers had >high school, children of
caregivers with <high school had higher odds of longer sleep latency ≥ 30 minutes (adjusted

OR=3.27; 95% CI=1.12-9.61) and longer WASO ≥ 90 minutes (OR=5.95; 95% CI=1.91-18.53).

Caregivers' education levels were significantly and inversely associated with children's sleep latency and WASO (both $P_{trend} < 0.05$). Children's short sleep duration (<8 hours) was not associated with caregivers' low educational level (OR=0.78; 95% CI=0.28-2.18).

The associations between caregivers' education and children's sleep efficiency varied little according to disability groups. For example, among children with mental and behavioral disorders, children of caregivers with <high school had lower sleep efficiency (beta=-6.2, SE=2.2; P=0.006), after adjustment for children's age, sex, caregiver-child relationship, and caregivers' age.

DISCUSSION

In this cross-sectional, pilot study, we assessed sleep patterns using wrist ActiSleep monitors over seven consecutive days among Chilean children with disabilities. We found that actigraphy-measured sleep disturbances including long sleep latency (median=27 minutes), long WASO (median=88 minutes), short sleep duration (median=8 hours), high number of nocturnal awakenings (mean=22), and low sleep efficiency (mean=80%) were common among children.

These findings indicate that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep fragmentation (increased nocturnal awakenings). These indices are common in insomnia, which may occur secondary to chronic health conditions, and for many conditions, is associated with poor quality of life and increased disease-specific health burden including behavioral and cognitive problems.^{26, 27} We also found strong associations between caregivers' low educational

1
2
3 attainment and sleep disturbances (e.g., low sleep efficiency) independent of children's disability
4 and other covariates from children and caregivers. To our knowledge, this is the first study to
5 specifically quantify actigraphy-measured sleep patterns and strong associations of caregivers'
6 low education levels with children's sleep disturbances.
7
8
9
10
11

12
13
14
15 Children with a wide range of disabilities have been reported to have sleep disturbances,
16 including prolonged sleep latency, increased WASO, and decreased sleep efficiency.^{4-6, 28, 29} In a
17 study of 8 UK children with mucopolysaccharidosis aged 2-15 years, median actigraphy-
18 measured sleep latency was 35.4 minutes, WASO 83.4 minutes, and sleep efficiency was
19 75.6%.²⁹ Allik et al reported that children aged 8-12 years with Asperger syndrome and high-
20 functioning autism in Sweden had actigraphy-measured longer sleep latency (mean=32 minutes)
21 and lower sleep efficiency (mean=87%) than controls.⁶ In a study of children aged 5-11 years
22 with ADHD in Denmark, average sleep latency was 26 minutes, 31% of children had sleep
23 latency >30 minutes.⁵ A case-control study using 5-night actigraphy for 15 school-aged children
24 with traumatic brain injury and 15 school-aged sibling in UK reported that brain injury was
25 significantly associated with children's longer sleep latency (mean=50 minutes), longer WASO
26 (mean=65 minutes), and lower sleep efficiency (mean=80%).²⁸ Gibbs et al reported that among 8
27 children aged 4-15 years with Prader-Willi syndrome in New Zealand, median 7-night
28 actigraphy-measured WASO was 95 minutes.³⁰ Corkum et al reported the average of awakenings
29 was 15 among Canadian children with ADHD (age: 7-11 years).⁴ In this study, we found a high
30 prevalence of actigraphy-measured sleep disturbances among Chilean children with disabilities:
31 43% of children had sleep latency \geq 30 minutes, and 78% had sleep efficiency <85%. Our study
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 along with previous research suggests that children with disabilities have difficulties initiating
4 and maintaining sleep.
5
6
7

8
9
10 Several researchers have reported that children with disabilities have late sleep onset.^{31,32} A
11 study of US children aged 2-5 years with autism and other developmental disabilities reported
12 that the mean of 7-day actigraphy-measured sleep onset was 21:32.³¹ In this study, we found that
13 median sleep onset was 22:39 among Chilean children with autism and other disabilities. Unique
14 climate (e.g., late sunset) and lifestyle characteristics (e.g., late mealtime) in the Patagonia region
15 may have partly contributed to children's late sleep time.^{13,33} Our findings of late sleep onset are
16 generally consistent with literature for children in this age range. For example, a cross-sectional
17 study of 96 healthy Chilean children aged 10 years found that the mean of overnight
18 polysomnography-measured sleep onset was 23:10 for children with normal weight and 23:20
19 for children with overweight and obesity.³⁴ Another study of 58 US healthy children aged 11-13
20 years showed that the mean of 4-day actigraphy-measured sleep onset was 23:27.³⁵ In the
21 Cleveland Children's Sleep and Health Study, 14.8% of US children aged 8-11 years had
22 bedtime 23:00 or later.¹⁴ Future research is warranted to examine how to improve sleep onset
23 time among children, especially among those with disabilities.
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45

46 It has been reported that children whose caregivers have low education levels are more likely to
47 have adverse health outcomes, such as greater body weight¹⁶ and lower quality of life.¹⁷

48 McDonald et al found that lower maternal education was independently associated with parent-
49 reported shorter sleep (<11 hours/night) among young children.¹² Although several studies have
50 reported that parental education is associated with child health,^{12,15} we are unaware of published
51
52
53
54
55
56
57
58
59
60

1
2
3 reports that have investigated whether and how caregivers' education levels are related to
4
5 objectively measured sleep patterns among children with disabilities. In our study, caregivers'
6
7 education in relation to children's sleep disturbances was substantiated through statistically
8
9 significant association as shown in univariate and multivariable linear and logistic regression
10
11 models. For example, after adjustment for children's age, sex, disability, caregiver-child
12
13 relationship, and caregivers' age, children of caregivers with <high school had 6.3% lower sleep
14
15 efficiency than children whose caregivers had >high school. Children of caregivers with <high
16
17 school were 2.27 times more likely to have sleep latency ≥ 30 minutes and were 4.95 times more
18
19 likely to have WASO ≥ 90 minutes when compared with children whose caregivers had >high
20
21 school. These findings suggest the importance of tailoring sleep education for caregivers with
22
23 lower educational attainment to improve children's sleep health. It may be important to provide
24
25 education and support that include sleep hygiene education and strategies to ensure necessary
26
27 social support for the less well-educated parents and families of children with disabilities.
28
29
30
31
32
33
34
35

36 Lack of knowledge of healthy sleep behaviors among caregivers has been associated with an
37
38 increased risk of having unhealthy sleep behaviors for their children.³⁶ Although sleep
39
40 disturbances have been noted to be common in children with neurological conditions (e.g.,
41
42 cerebral palsy), there are no interventions specifically designed to improve sleep in these
43
44 children.³⁷ Several small studies of children with ASD have reported that parent-based sleep
45
46 education appears effective in improving child sleep health.^{32, 38} A study of 20 children with
47
48 ASD showed that parent-based sleep education workshops improved sleep latency from 62.2
49
50 minutes to 45.6 minutes.³⁸ Malow et al reported that sleep education to parents of 80 children
51
52 with ASD (aged 2-10 years) significantly improved children's sleep onset from 58.2 to 39.6
53
54
55
56
57
58
59
60

1
2
3 minutes.³² Our prior qualitative study indicated that parental knowledge gaps regarding healthy
4
5
6 sleep behaviors in children support the need for increased sleep health education among targeted
7
8 caregivers.¹³ Pediatricians and family physicians can provide adequate advice and educational
9
10 messages (e.g., sleep health) to pediatric patients and their families.³⁹
11
12

13
14
15 Our study has several limitations. First, as this was a cross-sectional, pilot study, we did not have
16
17 a control group of children without disabilities. Second, this study was limited by its small
18
19 sample size and the heterogeneity of disabilities represented among children studied. As such,
20
21 we were not able to report associations specific to any single disability category (e.g., autism).
22
23
24 Third, we did not collect information pertaining to caregivers' sleep hygiene and other factors
25
26 such as co-sleeping. Hence we were not able to quantify the influence of these factors on
27
28 children's sleep patterns. Our findings also focused on caregivers (majority were mothers) of
29
30 children with disabilities in Chile, and may not be generalizable to other populations/groups.
31
32
33 Although characterized as an objective measure of sleep-wake cycle, actigraphy has its
34
35 limitations. For example, periods of quiet wakefulness may be interpreted by the device as sleep,
36
37 and periods of restless sleep may be interpreted by the device as wakefulness.^{8, 40} Despite this,
38
39 actigraphy has been well validated for objective estimation of nighttime sleep parameters across
40
41 age groups in the natural sleep environment.⁹
42
43
44
45
46
47

48 CONCLUSIONS

49
50
51 These findings indicate that children with disabilities frequently experience difficulties initiating
52
53 sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep
54
55
56
57

1
2
3 fragmentation (increased nocturnal awakenings). Among children with disabilities, lower levels
4
5 of caregivers' educational attainment are strongly and independently associated with children's
6
7 sleep disturbances. Parental support and education programs directed to families with low
8
9 education levels may be of particular importance for sleep behavior intervention among children
10
11 with disabilities. Larger studies are warranted to confirm our findings. Future research is also
12
13 needed regarding the effects of sleep education intervention as well as social support to low
14
15 educational families of children with disabilities on sleep health, with taking into account of
16
17 different cultural backgrounds.
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Contributors' Statement

All of the authors have agreed to the content of this manuscript. XC conceptualized and designed the study, supervised data collection, carried the initial analyses, and drafted the initial manuscript. JCV and CB carried out the field survey, supervised data collection, and critically reviewed and revised the manuscript. MP carried out the field survey, coordinated data collection at the study site, and reviewed the manuscript. BG helped develop the study protocol, and critically reviewed and revised the manuscript. SR critically reviewed and revised the manuscript. MAW provided funding support to the study, supervised the study, conceptualized and designed the study, and critically reviewed and revised the manuscript.

Competing Interests: The authors have no competing interests to disclose. The authors alone are responsible for the content and writing of the paper.

Funding Support: This research was supported by awards from the National Institutes of Health (National Institute on Minority Health and Health Disparities: T37-MD001449; the National Center for Research Resources (NCRR), the National Center for Advancing Translational Sciences (NCATS): 8UL1TR000170-07), and the Rose Traveling Award.

Ethics Approval: This study was approved by the institutional review boards of the Centro de Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human Research Administration.

Data Sharing Statement: No additional data are available.

REFERENCES

1. World report on disability 2011. World Health Organization.
http://www.who.int/disabilities/world_report/2011/report.pdf. Accessed October 20, 2014.
2. Churchill SS, Kieckhefer GM, Landis CA, Ward TM. Sleep measurement and monitoring in children with Down syndrome: A review of the literature, 1960-2010. *Sleep Med Rev*. 2012;16(5):477-488
3. Sung V, Hiscock H, Sciberras E, Efron D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the child and family. *Arch Pediatr Adolesc Med*. 2008;162(4):336-342
4. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep*. 2001;24(3):303-312
5. Hvolby A, Jorgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med*. 2008;162(4):323-329
6. Allik H, Larsson JO, Smedje H. Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *J Autism Dev Disord*. 2006;36(5):585-595
7. Sekine M, Chen X, Hamanishi S, Wang H, Yamagami T, Kagamimori S. The validity of sleeping hours of healthy young children as reported by their parents. *J Epidemiol*. 2002;12(3):237-242
8. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev*. 2002;6(2):113-124

- 1
2
3 9. Martin JL, Hakim AD. Wrist actigraphy. *Chest*. 2011;139(6):1514-1527
- 4
5
6 10. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcantara C, et al. Racial/Ethnic
7
8 Differences in Sleep Disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA).
9
10 *Sleep*. 2014 Nov 20. pii: sp-00459-14. [Epub ahead of print]
- 11
12
13 11. Mezick EJ, Matthews KA, Hall M, Strollo PJ, Jr., Buysse DJ, Kamarck TW, et al.
14
15 Influence of race and socioeconomic status on sleep: Pittsburgh SleepSCORE project.
16
17 *Psychosom Med*. 2008;70(4):410-416
- 18
19
20 12. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter
21
22 sleep in early childhood. *Sleep Med*. 2014;15(5):536-540
- 23
24
25 13. Chen X, Gelaye B, Velez JC, Pepper M, Gorman S, Barbosa C, et al. Attitudes, beliefs,
26
27 and perceptions of caregivers and rehabilitation providers about disabled children's sleep
28
29 health: a qualitative study. *BMC Pediatr*. 2014;14:245
- 30
31
32 14. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner HL, Redline S. Effects of
33
34 the home environment on school-aged children's sleep. *Sleep*. 2005;28(11):1419-1427.
- 35
36
37 15. Magana S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services
38
39 among latino children with autism spectrum disorders. *Intellec Dev Disabil*.
40
41 2013;51(3):141-153
- 42
43
44 16. Cameron AJ, van Stralen MM, Brug J, Salmon J, Bere E, Chinapaw MJ, et al. Television
45
46 in the bedroom and increased body weight: potential explanations for their relationship
47
48 among European schoolchildren. *Pediatr Obes*. 2013;8(2):130-141
- 49
50
51 17. Kumar S, Kroon J, Lalloo R. A systematic review of the impact of parental socio-
52
53 economic status and home environment characteristics on children's oral health related
54
55 quality of life. *Health Qual Life Outcomes*. 2014;12:41.
- 56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
18. Chen X, Gelaye B, Velez JC, Barbosa C, Pepper M, Andrade A, et al. Caregivers' hair cortisol: A possible biomarker of chronic stress is associated with obesity measures among children with disabilities. *BMC Pediatr.* 2015;15:9
 19. Chen X, Velez JC, Barbosa C, Pepper M, Andrade A, Stoner L, et al. Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress.* 2015;18(1):20-28
 20. ActiLife 6. ActiLife, ActiGraph R&D. <http://www.theactigraph.com/products/actisleep/>. Accessed November 12, 2014
 21. Disabilities. World Health Organization. <http://www.who.int/disabilities/>, accessed January 5, 2015
 22. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, et al. Estimating sleep patterns with activity monitoring in children and adolescents: how many nights are necessary for reliable measures? *Sleep.* 1999;22(1):95-103
 23. International Classification of Diseases (ICD-10). ICD-10 International Statistical Classification of Diseases and Related Health Problems. 10th Revision. Volume 2. Instruction manual Published 2010.
 24. Adkins KW, Molloy C, Weiss SK, Reynolds A, Goldman SE, Burnette C, et al. Effects of a standardized pamphlet on insomnia in children with autism spectrum disorders. *Pediatrics.* 2012;130 Suppl 2:S139-144
 25. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity (Silver Spring).* 2008;16(2):265-274
 26. Lipton J, Becker RE, Kothare SV. Insomnia of childhood. *Curr Opin Pediatr.* 2008;20(6):641-649

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
27. Malow BA, Byars K, Johnson K, Weiss S, Bernal P, Goldman SE, et al. A practice pathway for the identification, evaluation, and management of insomnia in children and adolescents with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S106-124
28. Sumpter RE, Dorris L, Kelly T, McMillan TM. Pediatric sleep difficulties after moderate-severe traumatic brain injury. *J Int Neuropsychol Soc*. 2013;19(7):829-834
29. Mahon LV, Lomax M, Grant S, Cross E, Hare DJ, Wraith JE, et al. Assessment of sleep in children with mucopolysaccharidosis type III. *PloS One*. 2014;9(2):e84128
30. Gibbs S, Wiltshire E, Elder D. Nocturnal sleep measured by actigraphy in children with Prader-Willi syndrome. *J Pediatr*. 2013;162(4):765-769
31. Goodlin-Jones BL, Tang K, Liu J, Anders TF. Sleep patterns in preschool-age children with autism, developmental delay, and typical development. *J Am Acad Child Adolesc Psychiatry*. 2008;47(8):930-938
32. Malow BA, Adkins KW, Reynolds A, Weiss SK, Loh A, Fawkes D, et al. Parent-based sleep education for children with autism spectrum disorders. *J Autism Dev Disord*. 2014;44(1):216-228
33. Velez JC, Fitzpatrick AL, Barbosa CI, Diaz M, Urzua M, Andrade AH. Nutritional status and obesity in children and young adults with disabilities in Punta Arenas, Patagonia, Chile. *Int J Rehabil Res*. 2008;31(4):305-313
34. Chamorro R, Algarin C, Garrido M, Causa L, Held C, Lozoff B, et al. Night time sleep macrostructure is altered in otherwise healthy 10-year-old overweight children. *Int J Obes (Lond)*. 2014;38(8):1120-1125

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
35. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc Health*. 2009;45(4):326-334
36. Owens JA, Jones C, Nash R. Caregivers' knowledge, behavior, and attitudes regarding healthy sleep in young children. *J Clin Sleep Med*. 2011;7(4):345-350
37. Galland BC, Elder DE, Taylor BJ. Interventions with a sleep outcome for children with cerebral palsy or a post-traumatic brain injury: a systematic review. *Sleep Med Rev*. 2012;16(6):561-573
38. Reed HE, McGrew SG, Artibee K, Surdkya K, Goldman SE, Frank K, et al. Parent-based sleep education workshops in autism. *J Child Neurol*. 2009;24(8):936-945
39. Halal CS, Nunes ML. Education in children's sleep hygiene: which approaches are effective? A systematic review. *J Pediatr*. 2014;90(5):449-456
40. Johnson KP, Giannotti F, Cortesi F. Sleep patterns in autism spectrum disorders. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):917-928

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure Legends

FIGURE 1 Children’s Sleep Parameters, by Caregiver Education Levels

For peer review only

TABLE 1 Characteristics of Children with Disabilities and Their Primary Caregivers

| | Total (n=125) | Boys (n=69) | Girls (n=56) | P value |
|---|----------------------|----------------------|----------------------|------------|
| Child characteristics | | | | |
| Age (years), mean (SD) | 9.2 (2.2) | 8.8 (2.1) | 9.8 (2.3) | 0.015 |
| Type of disability diagnosis, % | | | | |
| Mental and behavioral disorders | 48.0 | 59.4 | 33.9 | 0.004 |
| Diseases of musculoskeletal system | 16.8 | 10.1 | 25.0 | |
| Diseases of the nervous system | 27.2 | 27.5 | 26.8 | |
| Congenital/chromosomal abnormalities | 8.0 | 2.9 | 14.3 | |
| Sleep parameters | | | | |
| Sleep onset, median (IQR) | 22:39 (22:06, 23:08) | 22:44 (22:24, 23:08) | 22:32 (21:53, 23:09) | 0.183 |
| Sleep latency, median (IQR), minutes | 27.3 (15.0, 38.9) | 27.1 (14.4, 41.7) | 27.4 (15.4, 38.2) | 0.512 |
| WASO, median (IQR), minutes | 88.1 (65.6, 111.1) | 92.4 (64.4, 112.4) | 81.9 (66.2, 107.0) | 0.411 |
| Number of awakening, mean (SD) ^a | 22.1 (6.7) | 22.5 (6.5) | 21.6 (6.9) | 0.441 |

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

| | | | | |
|---|----------------|----------------|----------------|-------|
| Awakening length, median (IQR), minutes | 5.1 (4.2, 7.1) | 5.1 (4.2, 7.0) | 5.1 (4.2, 7.1) | 0.923 |
| Sleep duration, median (IQR), hours | 8.0 (7.5, 8.2) | 8.0 (7.3, 8.2) | 8.0 (7.5, 8.3) | 0.459 |
| Sleep efficiency, mean (SD), % ^a | 80.0 (7.2) | 79.0 (8.1) | 81.2 (5.8) | 0.072 |
| Caregiver characteristics | | | | |
| Age (years), mean (SD) | 38.0 (7.8) | 38.5 (7.8) | 38.0 (7.8) | 0.690 |
| Caregiver-child relationship, % | | | | |
| Mother | 88.0 | 88.4 | 87.5 | 0.877 |
| Other | 12.0 | 11.6 | 12.5 | |
| Education level, % | | | | |
| <High school | 21.6 | 24.6 | 17.9 | 0.088 |
| High school | 37.6 | 29.0 | 48.2 | |
| >High school | 40.8 | 46.4 | 33.9 | |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

^aOf these sleep parameters, only number of awakening and sleep efficiency were normally distributed (Kolmogorov-Smirnov test: $P > 0.05$). While Student's t-test was used for number of awakening and sleep efficiency, Wilcoxon rank-sum test was used for the other sleep parameters.

TABLE 2 Children's Sleep Parameters, By Caregivers' Education Levels

| Sleep parameters | <High school (n=27) | High school (n=47) | >High school (n=51) | P value |
|--|------------------------|-----------------------|------------------------|------------|
| Sleep onset, median (IQR) | 23:05 (22:17, 23:23) | 22:31 (21:55, 23:04) | 22:39 (22:24, 23:02) | 0.098 |
| Sleep latency, median (IQR), minutes | 35.6 (17.3, 53.7) | 27.1 (17.4, 38.4) | 23.6 (11.1, 35.9) | 0.031 |
| WASO, median (IQR), minutes | 99.1 (88.1, 121.0) | 77.1 (63.4, 103.4) | 77.0 (57.6, 106.0) | 0.006 |
| Number of awakening, mean (SD) ^a | 23.1 (5.7) | 21.2 (6.3) | 22.4 (7.5) | 0.470 |
| Awakening length, median (IQR), minutes | 6.9 (5.0, 9.5) | 5.2 (4.2, 7.2) | 4.7 (3.9, 5.7) | 0.001 |
| Sleep duration, median (IQR), hours | 7.9 (7.3, 8.4) | 8.0 (7.6, 8.2) | 8.0 (7.4, 8.2) | 0.852 |
| Sleep efficiency (%), mean (SD) ^a | 75.9 (7.0) | 80.5 (7.3) | 81.8 (6.5) | 0.002 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

^aSleep efficiency and number of awakening were normally distributed in this study.

TABLE 3 Linear Regression Models for Associations between Caregiver Education and Child Sleep Parameters

| | Number of awakening | | Sleep efficiency (%) | |
|---|-------------------------------|---------|----------------------|------------------|
| | Beta (SE) | P value | Beta (SE) | P value |
| <i>Univariate model</i> | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -1.2 (1.3) | 0.384 | -1.3 (1.4) | 0.357 |
| <High school | 0.7 (1.6) | 0.662 | -5.9 (1.7) | <0.001 |
| | <i>P value for trend test</i> | | | <i>0.001</i> |
| <i>Multivariable model^a</i> | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -0.6 (1.4) | 0.674 | -1.6 (1.4) | 0.269 |
| <High school | 1.9 (1.7) | 0.245 | -6.3 (1.7) | 0.001 |
| | <i>P value for trend test</i> | | | <i><0.001</i> |

Abbreviation: SE, standard error.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

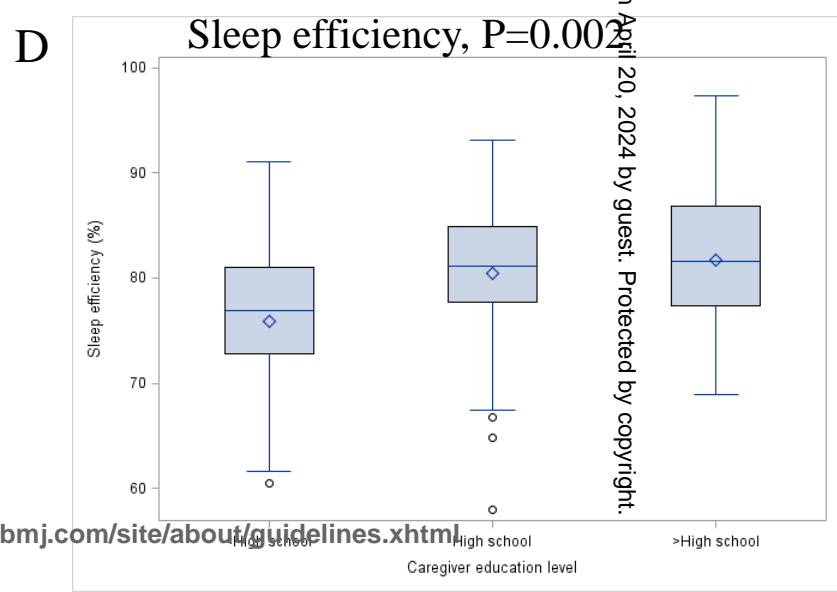
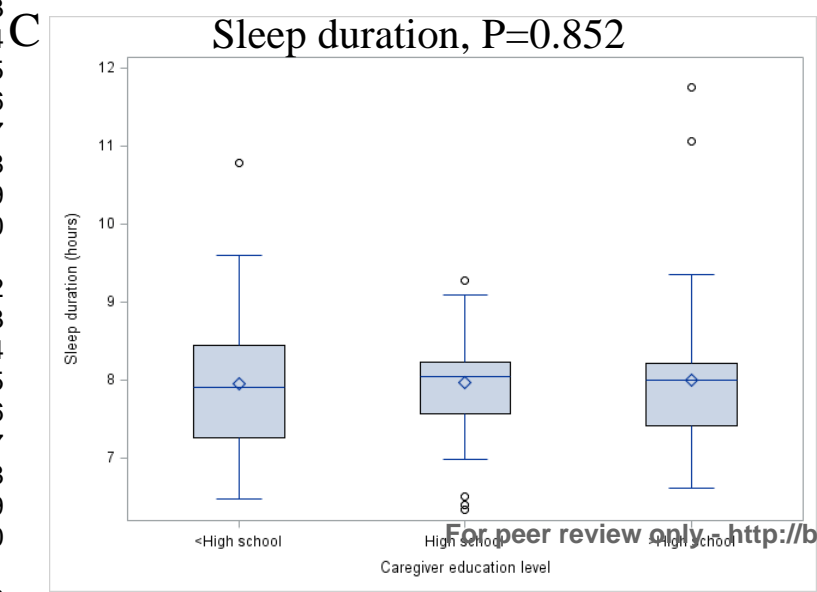
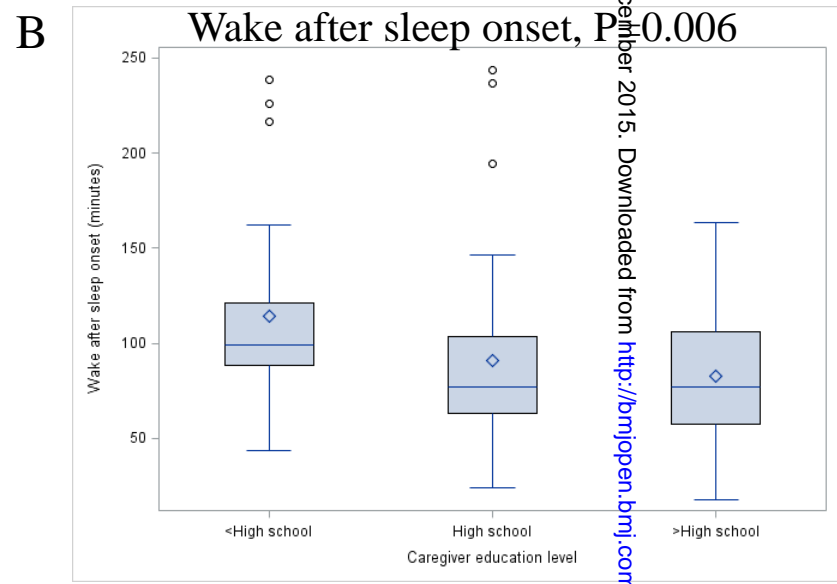
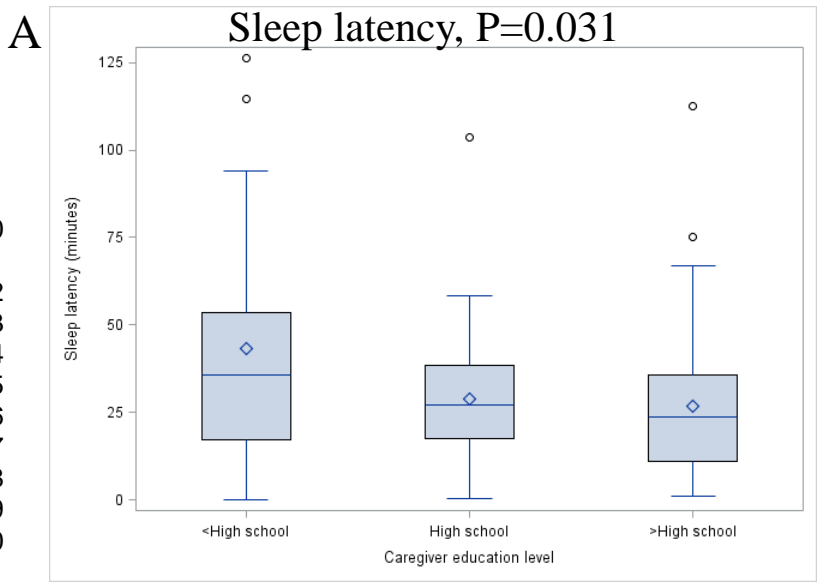
TABLE 4 Logistic Regression Models for Associations between Caregiver Education and Child Sleep Disturbances

| | Sleep latency ≥ 30 | | Long WASO ≥ 90 | | Sleep duration < 8 | |
|---|-------------------------------|---------|---------------------|---------|----------------------|---------|
| | vs. < 30 minutes | | vs. < 90 minutes | | vs. ≥ 8 hours | |
| | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) | P value |
| <i>Univariate model</i> | | | | | | |
| Caregiver education (ref: $>$ high school) | | | | | | |
| High school | 0.95 (0.42, 2.17) | 0.911 | 1.36 (0.61, 3.04) | 0.449 | 0.72 (0.33, 1.60) | 0.424 |
| $<$ High school | 3.37 (1.26, 8.98) | 0.015 | 4.43 (1.58, 12.38) | 0.005 | 0.89 (0.35, 2.25) | 0.797 |
| | <i>P value for trend test</i> | | | | | |
| | | 0.029 | | 0.006 | | 0.689 |
| <i>Multivariable model</i> | | | | | | |
| Caregiver education (ref: $>$ high school) ^a | | | | | | |
| High school | 1.02 (0.42, 2.45) | 0.966 | 1.38 (0.58, 3.30) | 0.468 | 0.70 (0.30, 1.64) | 0.408 |
| $<$ High school | 3.27 (1.12, 9.61) | 0.031 | 5.95 (1.91, 18.53) | 0.002 | 0.78 (0.28, 2.18) | 0.629 |
| | <i>P value for trend test</i> | | | | | |
| | | 0.056 | | 0.004 | | 0.526 |

Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; WASO, wake after sleep onset.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

FIGURE 1 Children’s Sleep Parameters, by Caregiver Education Levels



0085889 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

Supplementary Table 1 Children's Sleep Parameters, By Types of Disability Diagnosis

| Sleep parameters | Diagnosis I (n=60) | Diagnosis II (n=21) | Diagnosis III (n=34) | Diagnosis IV (n=10) | P value |
|---|-----------------------|------------------------|-------------------------|------------------------|------------|
| Sleep onset, median (IQR) | 22:35 (22:04, 23:03) | 23:05 (22:25, 23:22) | 22:37 (22:19, 23:05) | 22:35 (21:45, 23:03) | 0.187 |
| Sleep latency, median (IQR), minutes | 24.1 (14.7, 40.1) | 28.1 (22.1, 43.0) | 28.8 (14.1, 38.4) | 30.5 (9.1, 39.4) | 0.804 |
| WASO, median (IQR), minutes | 78.4 (63.5, 104.9) | 103.3 (75.0, 123.7) | 89.1 (61.7, 100.0) | 94.0 (69.9, 117.9) | 0.252 |
| Number of awakening, mean (SD) ^a | 22.4 (6.6) | 25.1 (5.1) | 19.3 (6.5) | 23.6 (7.6) | 0.011 |
| Sleep duration, median (IQR), hours | 8.0 (7.7, 8.3) | 7.6 (7.0, 8.0) | 8.0 (7.4, 8.3) | 7.8 (7.1, 8.5) | 0.138 |
| Sleep efficiency, mean (SD), % ^a | 81.2 (6.5) | 78.2 (6.2) | 79.5 (8.6) | 78.3 (8.2) | 0.309 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

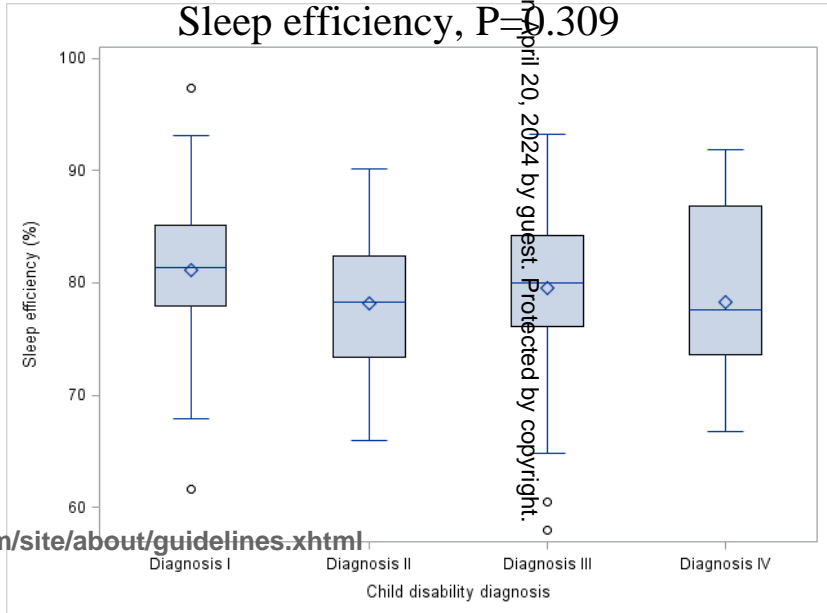
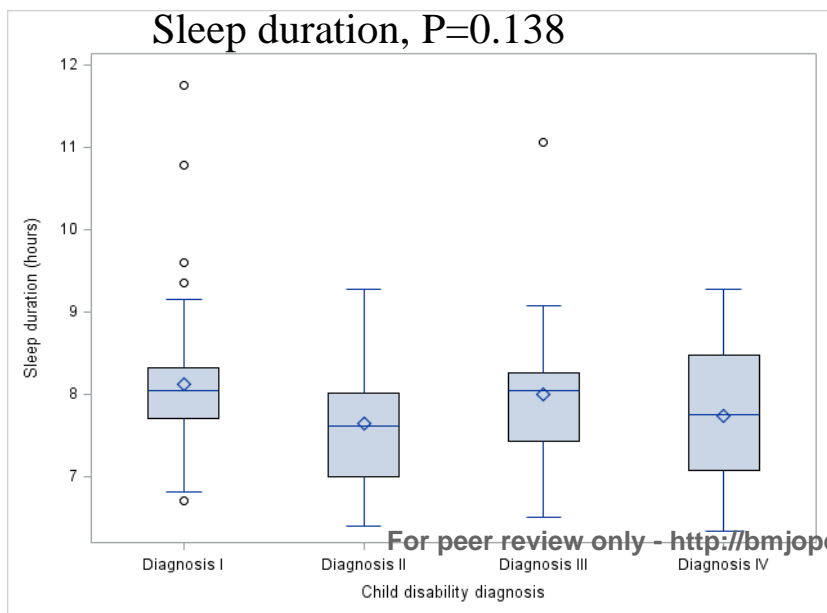
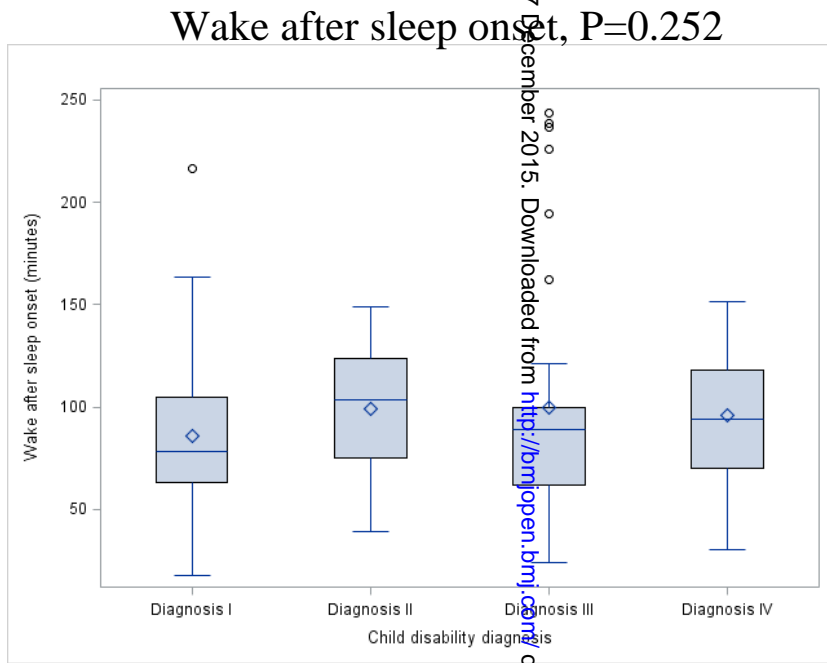
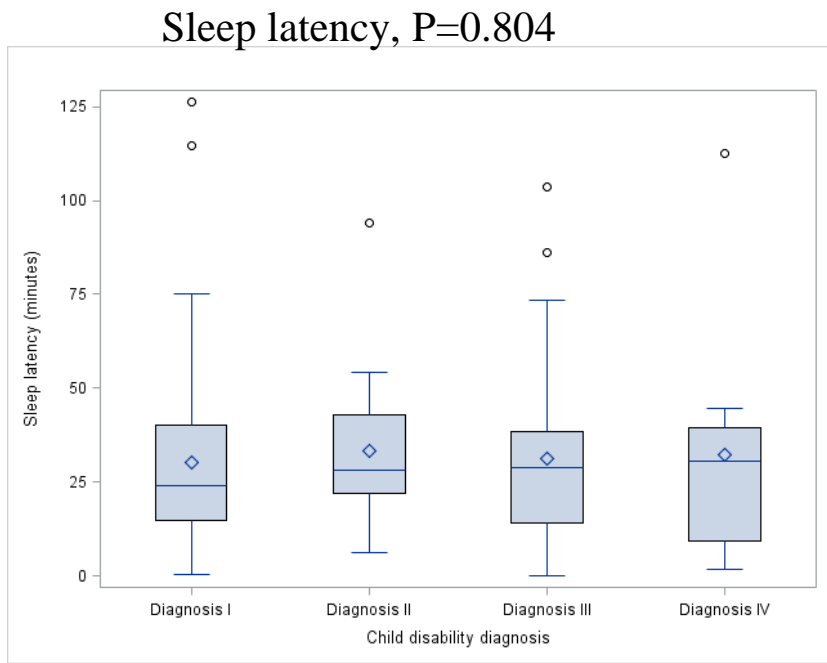
Only sleep efficiency (%) and number of awakening were normally distributed (Kolmogorov-Smirnov test: $P > 0.05$).

^aAnalysis of variance was used for sleep efficiency and number of awakening (normally distributed), while Kruskal-Wallis test was used for other sleep parameters.

Diagnosis I: mental and behavioral disorders (e.g., autism, ADHD, mental retardation); Diagnosis II: diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); Diagnosis III: diseases of the nervous system (e.g., cerebral palsy); Diagnosis IV: congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

SUPPLEMENTARY FIGURE 1 Children's Sleep Parameters, by Disability Group

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42



0-085895 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|------------------------------|---------|---|
| Title and abstract | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including hypotheses |
| Methods | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (a) <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement). |
| Bias | 9 | |
| Study size | 10 | This is a cross-sectional, pilot study. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions |
| Results | | |
| Participants | 13 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| Descriptive data | 14 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| Outcome data | 15 | <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

Discussion

| | | |
|------------------|----|--|
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

Other information

| | | |
|---------|----|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study. |
|---------|----|---|

For peer review only

BMJ Open

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID: | bmjopen-2015-008589.R1 |
| Article Type: | Research |
| Date Submitted by the Author: | 28-Jul-2015 |
| Complete List of Authors: | Chen, Xiaoli; Harvard T.H. Chan School of Public Health, Department of Epidemiology Velez, Juan Carlos; Centro de Rehabilitación Club de Leones Cruz del Sur, Barbosa, Clarita; Centro de Rehabilitación Club de Leones Cruz del Sur, Pepper, Micah; Centro de Rehabilitación Club de Leones Cruz del Sur, Gelaye, Bizu; Harvard T.H. Chan School of Public Health, Department of Epidemiology Redline, Susan; Brigham and Women's Hospital, Division of Sleep and Circadian Disorders; Harvard Medical School, Department of Medicine Williams, Michelle; Harvard T.H. Chan School of Public Health, Department of Epidemiology |
| Primary Subject Heading: | Paediatrics |
| Secondary Subject Heading: | Public health, Epidemiology |
| Keywords: | SLEEP MEDICINE, Community child health < PAEDIATRICS, PUBLIC HEALTH, EPIDEMIOLOGY |
| | |

SCHOLARONE™
Manuscripts

only

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities

Xiaoli Chen, MD, MPH, PhD*¹, Juan Carlos Velez, MD², Clarita Barbosa, MD², Micah Pepper, MPH², Bizu Gelaye, MPH, PhD¹, Susan Redline, MD, MPH^{1,3,4}, Michelle A. Williams, ScD¹

¹Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA 02115, USA

²Centro de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile

³Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston MA 02115

⁴Department of Medicine, Harvard Medical School, Boston, MA 02115, USA

***Address correspondence to:** Xiaoli Chen, MD, MPH, PhD, Department of Epidemiology, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, Phone: 617-432-0067, xchen@hsph.harvard.edu

SHORT TITLE: Sleep patterns among children with disabilities

Abstract: 266 words

Text: 4165 words

Tables: 4; Figures: 1

Supplementary table: 1

Supplementary figure: 1

KEY WORDS

Child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

ABBREVIATIONS

ADHD: attention-deficit/hyperactivity disorder

ASD: autism spectrum disorder

CI: confidence interval

CPASS: Chile Pediatric and Adult Sleep and Stress Study

ICD: International Classification of Diseases

ICF-CY: International Classification of Functioning, Disability and Health for Children and Youth

1
2
3
4 IQR: interquartile range
5 OR: odds ratio
6 SD: standard deviation
7 SE: standard error
8 WASO: wake after sleep onset
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

Abstract

Objectives: To characterize actigraphy-measured sleep patterns among children with disabilities and to examine whether caregivers' education is associated with sleep disturbances.

Design: Cross-sectional study.

Setting: A rehabilitation center in the Patagonia region, Chile.

Methods: This pilot and feasibility study was conducted among 125 children aged 6-12 years with disabilities (boys: 55.2%) and caregivers in Chile. Children wore ActiSleep monitors for seven days. General linear models were fitted to generate least-square means and standard errors (SEs) of sleep efficiency (proportion of the sleep period spent sleeping) across caregivers' education levels adjusting for children's age, sex, disability type, caregiver-child relationship, and caregivers' age. Multivariable logistic regression analyses were conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of longer sleep latency (≥ 30 minutes) and longer wake after sleep onset (WASO) (≥ 90 minutes) (a measure of sleep fragmentation) in relation to caregivers' educational attainment.

Results: Median sleep latency was 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours. Mean sleep efficiency was 80.0%. Caregivers' education was positively and significantly associated with children's sleep efficiency ($P_{trend}=0.001$). Adjusted mean sleep efficiency was 75.7% (SE=1.4) among children of caregivers <high school, and 81.9% (SE=1.0) among children of caregiver >high school. Compared to children whose caregivers had >high school, children of caregivers with <high school had higher odds of longer sleep latency (OR=3.27; 95%

1
2
3
4
5
6 CI=1.12-9.61) and longer WASO (OR=5.95; 95% CI=1.91-18.53). Associations were consistent
7
8 across disability types.
9

10
11 **Conclusions:** Children with disabilities experience difficulties initiating sleep (prolonged sleep
12 latency) and maintaining sleep (long WASO, low sleep efficiency). Among children with
13 disabilities, lower caregiver education level is associated with more sleep disturbances.
14
15

16
17
18
19 **KEY WORDS:** child, disability, caregiver, education, sleep parameter, actigraphy, sleep
20 duration, sleep efficiency, sleep latency, wake after sleep onset
21
22
23

24 25 26 27 **Strengths and limitations of this study** 28

- 29
30 ■ This cross-sectional pilot and feasibility study is strengthened by its use of actigraphy
31 which has been well validated for objective estimation of nighttime sleep parameters in
32 the natural sleep environment.
33
- 34
35 ■ Our study was unique in being the first study to examine the associations between
36 caregivers' education and actigraphy-measured sleep among children with disabilities.
37
- 38
39 ■ Its strength also lies in the statistical analysis that was performed using univariate and
40 multivariable linear and logistic regression models.
41
- 42
43 ■ This is a cross-sectional, pilot study with a small sample size and high heterogeneity of
44 disabilities included.
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

INTRODUCTION

Approximately 150 million children live with disabilities worldwide.¹ Sleep disturbances, particularly difficulty initiating and maintaining sleep, are commonly reported among children with a wide range of disabilities including Down syndrome, attention-deficit/hyperactivity disorder (ADHD), and autism.²⁻⁶ There are discrepancies between objective measures of sleep and those reported by parents of children with disabilities.⁵ Parents may be unaware of children's sleep disturbances, such as night awakenings, and tend to overestimate their children's sleep duration.⁷ Inferences from prior studies are limited because investigators have relied on parental report of child sleep.³ Although polysomnography is considered the gold standard for measuring sleep, it is burdensome and not easily amenable for use with children who have difficulties sleeping in unfamiliar surroundings. Actigraphy-based sleep offers opportunities to obtain objective measures of sleep in children's typical environment. Actigraphy has been validated for objective measures of sleep in clinical- and population-based studies.^{8,9}

Sleep disturbances have been related to sociodemographic, environmental, and behavioral factors.¹⁰⁻¹³ Children's sleep disturbances have been connected with their home environment that may be influenced by caregivers' characteristics.^{13,14} Our recent qualitative study showed that while Chilean caregivers and rehabilitation providers recognized the importance of sleep health, they differed in their understanding of how sleep practices influence sleep health.¹³ Parental ability to provide support for healthy behaviors including sleep may be influenced by parental education, a known factor associated with child health measures.^{12,15-17} Magana et al reported

1
2
3
4
5
6 that maternal education and knowledge about autism accounted for differences in the number of
7 specialty services received by Latino children with autism spectrum disorder (ASD) as compared
8 with White children in the US.¹⁵ However, to our knowledge, little research has been conducted
9 regarding the role of caregivers' education in objectively measured sleep among children with
10 disabilities, particularly among Patagonian Chilean children, an understudied population with
11 documented high burden of obesity and related chronic disorders.¹⁸
12
13
14
15
16
17
18
19
20
21
22

23 This cross-sectional pilot and feasibility study aimed to characterize actigraphy-measured sleep
24 patterns and to examine whether caregivers' education is associated with sleep disturbances
25 among children with disabilities, conducted to inform future research in this population. We
26 sought to estimate the prevalence of actigraphy-measured sleep disturbances including long sleep
27 latency, long wake after sleep onset (WASO), short sleep duration, and poor sleep quality (low
28 sleep efficiency) among Chilean children with disabilities. Further, following up on results from
29 a previous qualitative study,¹³ we sought to determine the extent to which, if at all, caregivers'
30 low levels of educational attainment are associated with children's sleep disturbances and overall
31 poor sleep quality.
32
33
34
35
36
37
38
39
40
41
42
43
44
45

46 **METHODS**

47 **Participants**

48 The Chile Pediatric and Adult Sleep and Stress Study (CPASS) was a cross-sectional pilot and
49 feasibility study that was established in September 2012 at the Centro de Rehabilitacion Club de
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 Leones Cruz del Sur in Punta Arenas, Chile.¹³ The first wave of the CPASS (CPASS I) was
7
8 conducted between September and December in 2012 among children aged 6-12 years who were
9
10 receiving routine clinical care for disabilities at the center and their primary caregivers who were
11
12 parents, grandparents, relatives, or other adults and were principally responsible for children's
13
14 well-being and did not have developmental or intellectual disabilities. Children with disabilities
15
16 in this study were those who had impairments, activity limitations, participation restrictions due
17
18 to health conditions such as autism, Down's Syndrome, and cerebral palsy, according to the
19
20 World Health Organization, the International Classification of Functioning, Disability and Health
21
22 for Children and Youth (ICF-CY).¹⁹ All the children were diagnosed by a clinical care team
23
24 composed by a pediatric neurologist, a pediatrician with extensive experience in developmental
25
26 disabilities, and a rehabilitation medicine specialist using diagnostic criteria and/or standardized
27
28 tests with the input of families and teachers. The trained research staff talked with caregivers to
29
30 determine if they could complete the interviewer-administered questionnaire survey. In addition,
31
32 a physician helped confirm that caregivers had no developmental or intellectual disabilities. Of
33
34 153 children whose families were contacted via telephone by research staff, 110 adult caregivers
35
36 (72%) consented to participate in this study. A total of 110 children and caregivers (one
37
38 caregiver per child) were recruited in the CPASS I. Five children were excluded from this study
39
40 due to fewer than 3 days of actigraphy data: four children removed monitors after day one or day
41
42 two of the study and/or without sleep log data; one child lost the monitor on day two. A total of
43
44 105 child-caregiver dyads (95.5% of enrolled families) completed the CPASS I study protocol.
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 The second wave of the CPASS (CPASS II) was conducted among children with disabilities
7 aged 10-21 years and their primary caregivers between April and July in 2013 at the center.^{20,21}
8
9 Research personnel invited 129 caregivers of children with disabilities to participate. A total of
10
11 90 caregivers (72%) agreed to participate in the study. Twenty children were aged 10-12 years
12
13 from the CPASS II. As these two studies (CPASS I and CPASS II) were conducted between
14
15 September 2012 and July 2013 at the same rehabilitation center in Chile, with the same staff and
16
17 with identical study protocols used for assessing sleep traits, we combined the results from the
18
19 two studies in order to have a larger sample size with increased statistical power in the present
20
21 analysis. In total, 125 children aged 6-12 years were included in the current study.
22
23
24
25
26
27
28

29 Written informed consents were obtained from primary caregivers of children with disabilities.
30
31 This study was approved by the institutional review boards of the Centro de Rehabilitacion Club
32
33 de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human
34
35 Research Administration.
36
37
38
39
40

41 **Study Procedures**

42
43 A psychologist administered structured questionnaires to caregivers to collect information on
44
45 sociodemographic and lifestyle factors of children and caregivers. Research staff instructed
46
47 children to wear ActiSleep monitors (ActiLife, ActiGraph R&D, Florida, USA)²² on their non-
48
49 dominant wrists for seven consecutive days. Although the monitors are waterproof, children
50
51 were instructed to remove them from their wrists before taking showers and before swimming.
52
53
54
55
56
57
58
59
60

Caregivers were also instructed to keep sleep logs of time in bed and time out of bed for their children. Electronic medical records were reviewed by a physician in order to extract children's diagnoses defined by the International Classification of Diseases (ICD-10).²³

Sleep Parameters

Actigraphic sleep data were collected using the ActiSleep monitors and were analyzed using the ActiLife 6 data analysis software.²² When worn during sleep episodes, the ActiSleep monitor can provide estimates of sleep onset, sleep latency, WASO, number and length of awakenings, sleep duration, and sleep efficiency. Sleep latency is the length of time taken to fall asleep, calculated as the time between "lights off" to the first period of 3 minutes of consecutive epochs scored as sleep. WASO is the number of minutes awake between sleep onset and time of final waking. Sleep efficiency is defined as the proportion of the estimated sleep periods spent asleep. Actigraphy data were collected in 1-min epochs using the zero-crossing modes, and the "Sadeh" sleep algorithm was used for children.²⁴ The majority of children (n=122, 97.6 %) had complete 7-day actigraphic sleep data; two children had 6-day actigraphic data and one child had 3-day data available for study. The averages of sleep parameters were calculated for children who had 3, 6, or 7 days of actigraphic data. There were no missing sleep log data for children included in this study. Caregivers were asked to record their children's sleep logs each morning up awakening and checked their sleep logs when caregivers returned with ActiSleep monitors. Information from sleep logs were not used to substitute missing actigraphy data.

Sociodemographic Characteristics and Children's Disabilities

Interviewer-administered questionnaires were used to collect information on children's age, sex, daytime napping, medication use, caregiver-child relationship (e.g., mother), caregivers' age, employment status, and education level. Caregivers were asked to report the highest degree of education they had completed: less than 12th grade, high school graduate or equivalent, some college degree, or college graduate or above. According to the ICD-10,²³ children's disabilities were grouped as: 1) mental and behavioral disorders (e.g., autism, ADHD); 2) diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); 3) diseases of the nervous system (e.g., cerebral palsy); and 4) congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

Statistical Analysis

Kolmogorov-Smirnov test was used to assess the normality of sleep parameters. Variables were described using means and standard deviations (SDs) for parametric variables and medians and interquartile ranges (IQRs) for nonparametric variables. Student's t-test was used for age, sleep efficiency, and number of awakening as parametric variables by child sex; Wilcoxon rank-sum test was used to test differences in nonparametric variables including sleep onset, sleep latency, WASO, awakening length, and sleep duration by child sex. Fisher's or χ^2 test was conducted to compare differences in sociodemographic factors, daytime napping, medication use, and disability groups by child sex. Analysis of variance or Kruskal-Wallis test was conducted to

1
2
3
4
5
6 evaluate differences in sleep parameters across children's disability groups and caregivers'
7
8 education levels.
9

10
11
12
13 A general linear model was fitted to generate least-square means and standard errors (SEs) of
14
15 sleep efficiency across caregivers' education levels with adjustment for children's age, sex,
16
17 disability, caregiver-child relationship, and caregivers' age. Univariate and multivariable linear
18
19 regression analyses were performed to examine the associations of caregivers' education level
20
21 with sleep efficiency and the number of awakenings. Stratified analysis was conducted to
22
23 evaluate whether associations between caregivers' education and children's sleep disturbances
24
25 differed according to children's disability groups. As sleep latency, WASO, and sleep duration
26
27 were not normally distributed and given that we aimed to examine whether children whose
28
29 caregivers had lower education level were more likely to have sleep disturbances (e.g., long
30
31 sleep latency, long WASO) and to enhance interpretability, we created categorical variables for
32
33 these sleep parameters and used in logistic regression models. Odds ratios (ORs) and 95%
34
35 confidence intervals (CIs) were estimated using logistic regression models to evaluate the
36
37 associations of caregivers' educational attainment with children's long sleep latency (≥ 30 vs.
38
39 < 30 minutes), long WASO (≥ 90 vs. < 90 minutes), and short sleep duration (< 8 vs. ≥ 8 hours).
40
41 These cut points were chosen based on the literature of sleep latency²⁵ and sleep duration,²⁶ as
42
43 well as sleep data distributions in the study (WASO median=88 minutes, sleep duration
44
45 median=8 hours; only 9.6% of children had sleep ≥ 9 hours). We also included a variable to
46
47 represent study wave (I and II) in multivariable regression models and found similar results (data
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 not shown). We conducted sensitivity analysis by including medication use and daytime napping
7
8 in the models and did not find that they had an impact on our results in this study (data not
9
10 shown). Statistical significance levels were set at $P < 0.05$ for two-sided analyses. P values were
11
12 not corrected for multiple testing. All tests were performed using SAS 9.3 (SAS Institute, Cary,
13
14 NC).
15
16

17 18 19 20 21 RESULTS

22 The mean age of children with disabilities was 9.2 (SD=2.2; range 6-12) years. Most caregivers
23
24 were mothers (88.0%); 21.6% of caregivers reported having <high school education level (**Table**
25
26 **1**). There were no statistically significant differences in medication use, daytime napping,
27
28 caregiver-child relationship, caregivers' age, employment status, or education level between
29
30 boys and girls.
31
32

33
34
35
36
37 Median time for sleep onset was 22:39, sleep latency 27.3 minutes, WASO 88.1 minutes, and
38
39 sleep duration 8.0 hours (**Table 1**). Mean number of awakening was 22.1, sleep efficiency
40
41 80.0%. There were no statistically significant differences in sleep parameters between boys and
42
43 girls (all $P > 0.05$). Overall, 43.2% of children had sleep latency ≥ 30 minutes, 51.2% had short
44
45 sleep <8 hours, and 77.6% had low sleep efficiency <85%.
46
47

48
49
50
51 There were no significant differences in sleep parameters across disability groups
52
53 (**Supplementary Figure 1**), except for the number of nocturnal awakening (**Supplementary**
54
55

1
2
3
4
5
6 **Table 1).** Children with diseases of musculoskeletal system and connective tissue, skin and
7
8 subcutaneous tissue appeared to have more awakenings, reflecting more fragmented sleep, than
9
10 children with other disabilities.
11
12

13
14
15 Children whose caregivers had <high school had longer sleep latency, longer WASO, longer
16
17 awakening length, and lower sleep efficiency compared to children whose caregivers had >high
18
19 school (**Figure 1, Table 2**). Although children of caregivers with <high school tended to have
20
21 later sleep onset, higher number of awakenings, and shorter sleep duration when compared to
22
23 children of caregivers with higher education, these differences did not reach statistical
24
25 significance.
26
27
28
29

30
31
32 After adjustment for child age, sex, disability group, caregiver-child relationship, and caregiver
33
34 age, mean sleep efficiency was the lowest among children of caregivers with <high school
35
36 (75.7% [SE=1.4]), followed by children of caregivers with high school (80.4% [SE=1.0]) and
37
38 >high school (81.9% [SE=1.0]). Linear regression analyses showed no significant associations
39
40 between caregivers' education levels and children's awakening number. However, compared to
41
42 children whose caregivers had >high school, children of caregivers with <high school had
43
44 significantly lower sleep efficiency (adjusted beta=-6.3, SE=1.7; P=0.001) (**Table 3**).
45
46
47

48
49 Caregivers' educational attainment was significantly and positively associated with children's
50
51 sleep efficiency ($P_{trend}=0.001$).
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 As shown in **Table 4**, compared to children whose caregivers had >high school, children of
7
8 caregivers with <high school had higher odds of longer sleep latency ≥ 30 minutes (adjusted
9
10 OR=3.27; 95% CI=1.12-9.61) and longer WASO ≥ 90 minutes (OR=5.95; 95% CI=1.91-18.53).
11
12 Caregivers' education levels were significantly and inversely associated with children's sleep
13
14 latency and WASO (both $P_{trend} < 0.05$). Children's short sleep duration (<8 hours) was not
15
16 associated with caregivers' low educational level (OR=0.78; 95% CI=0.28-2.18).
17
18
19
20

21
22 The associations between caregivers' education and children's sleep efficiency varied little
23
24 according to disability groups (data not shown in tables). For example, among children with
25
26 mental and behavioral disorders, children of caregivers with <high school had lower sleep
27
28 efficiency (beta=-6.2, SE=2.2; P=0.006), after adjustment for children's age, sex, caregiver-child
29
30 relationship, and caregivers' age. Similar results were found for children with other disabilities.
31
32
33
34
35
36

37 DISCUSSION

38
39 In this cross-sectional pilot and feasibility study, we assessed sleep patterns using wrist
40
41 actigraphy over seven consecutive days among Chilean children with disabilities. We found that
42
43 actigraphy-measured sleep disturbances including long sleep latency (median=27 minutes), long
44
45 WASO (median=88 minutes), short sleep duration (median=8 hours), high number of nocturnal
46
47 awakenings (mean=22), and low sleep efficiency (mean=80%) were common among children.
48
49 These findings indicate that children with disabilities frequently experience difficulties initiating
50
51 sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency), and
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 have increased sleep fragmentation (increased nocturnal awakenings). These indices are common
7
8 in insomnia, which may occur secondary to chronic health conditions, and for many conditions,
9
10 is associated with poor quality of life and increased disease-specific health burden including
11
12 behavioral and cognitive problems.^{27,28} We also found strong associations between caregivers'
13
14 low educational attainment and children's sleep disturbances (e.g., low sleep efficiency)
15
16 independent of children's disability and other covariates from both children and caregivers. To
17
18 our knowledge, this is the first study to specifically quantify actigraphy-measured sleep patterns
19
20 with caregivers' low education levels with children with disabilities. Furthermore, we address
21
22 these questions among Patagonian Chilean children with disabilities, an understudied population
23
24 in South America.
25
26
27
28
29
30
31

32 Children with a wide range of disabilities have been reported to have sleep disturbances,
33
34 including prolonged sleep latency, increased WASO, short sleep duration, and decreased sleep
35
36 efficiency in Europe and other developed countries including Canada and New Zealand.^{4-6, 29, 30}
37
38 For example, in a small study of 8 UK children with mucopolysaccharidosis aged 2-15 years,
39
40 median actigraphy-measured sleep latency was 35.4 minutes, WASO 83.4 minutes, and sleep
41
42 efficiency was 75.6%.³⁰ Allik et al reported that children aged 8-12 years with Asperger
43
44 syndrome and high-functioning autism in Sweden had actigraphy-measured longer sleep latency
45
46 (mean=32 minutes) and lower sleep efficiency (mean=87%) than controls.⁶ In a study of children
47
48 aged 5-11 years with ADHD in Denmark, average sleep latency was 26 minutes and 31% of
49
50 children had sleep latency >30 minutes.⁵ A case-control study using 5-night actigraphy for 15
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 school-aged children with traumatic brain injury and 15 school-aged sibling in UK reported that
7
8 brain injury was significantly associated with children's longer sleep latency (mean=50 minutes),
9
10 longer WASO (mean=65 minutes), and lower sleep efficiency (mean=80%).²⁹ To our
11
12 knowledge, no research has been conducted on objectively measured sleep parameters in South
13
14 American (e.g., Chile) among children with disabilities, an understudied sample. In our study of
15
16 Chilean children with autism and other disabilities, the median of actigraphy-measured sleep
17
18 latency was 27 minutes, WASO was 88 minutes, and the mean of sleep efficiency was 80%,
19
20 which were similar to several previous research findings.^{5, 29, 30} We also found that a high
21
22 proportion of Chilean children with disabilities experience actigraphy-measured sleep
23
24 disturbances: 43% of children had sleep latency ≥ 30 minutes, 51% had short sleep <8 hours
25
26 (90% of children had sleep duration <9 hours), and 78% had sleep efficiency <85%. Although
27
28 the recommendations are for school-aged children to have at least 9 hours of sleep,^{26, 31} in our
29
30 study, only 10% of Chilean children with disabilities had sleep duration ≥ 9 hours. Gibbs et al
31
32 reported that among 8 children aged 4-15 years with Prader-Willi syndrome in New Zealand,
33
34 median 7-night actigraphy-measured WASO was 95 minutes.³² Corkum et al reported the
35
36 average of awakenings was 15 among Canadian children with ADHD (age: 7-11 years).⁴ In our
37
38 current study, the average of nocturnal awakenings was 22 among Chilean children with ADHD
39
40 and other disabilities. Our study along with previous research suggests that children with
41
42 disabilities have difficulties initiating and maintaining good sleep.
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 Several researchers have reported that children with disabilities have late sleep onset.^{33,34} A
7
8 study of US children aged 2-5 years with autism and other developmental disabilities reported
9
10 that the mean of 7-day actigraphy-measured sleep onset time was 21:32.³³ In this study, we
11
12 found that median sleep onset time was 22:39 among Chilean children with autism and other
13
14 disabilities. Unique climate (e.g., late sunset) and lifestyle characteristics (e.g., late mealtime) in
15
16 the Patagonia region may have partly contributed to children's late sleep time.^{13,18} Our findings
17
18 of late sleep onset are generally consistent with literature for children in this age range. For
19
20 example, a cross-sectional study of 96 healthy Chilean children aged 10 years found that the
21
22 mean of overnight polysomnography-measured sleep onset time was 23:10 for children with
23
24 normal weight and 23:20 for children with overweight and obesity.³⁵ Another study of 58 US
25
26 healthy children aged 11-13 years showed that the mean of 4-day actigraphy-measured sleep
27
28 onset time was 23:27.³⁶ In the Cleveland Children's Sleep and Health Study, 14.8% of US
29
30 children aged 8-11 years had bedtime 23:00 or later.¹⁴ Future research is warranted to examine
31
32 potential risk factors of late bedtime such as daytime napping and how to improve sleep onset
33
34 time among children, especially among those with disabilities.
35
36
37
38
39
40
41
42

43
44 It has been reported that children whose caregivers have low education levels are more likely to
45
46 have adverse health outcomes, such as greater body weight¹⁶ and lower quality of life.¹⁷
47
48 McDonald et al found that lower maternal education was independently associated with parent-
49
50 reported shorter sleep (<11 hours/night) among young children.¹² Although several studies have
51
52 reported that parental education is associated with child health,^{12, 15} we are unaware of published
53
54
55
56
57
58
59
60

1
2
3
4
5
6 reports that have investigated whether and how caregivers' education levels are related to
7
8 objectively measured sleep problems among children with disabilities. In our study, caregivers'
9
10 education level in relation to children's sleep disturbances was substantiated through statistically
11
12 significant association as shown in univariate and multivariable linear and logistic regression
13
14 models. Our study suggests the importance of tailoring sleep education for caregivers with lower
15
16 educational attainment to improve children's sleep health. We considered low educational
17
18 attainment a proxy for low socioeconomic status (SES). It has been reported that educational
19
20 levels and SES are highly correlated.³⁷ Low SES, as well as low education, has been related to
21
22 high risks for cardiovascular disease, cancer, and mortality.³⁸ Parental SES has been reported to
23
24 be inversely associated with child health consequences including cardiovascular disease and
25
26 mortality.^{39,40} Some of the burden from low parental education level may be attributable to
27
28 relatively lower health literacy, particularly sleep health literacy, which is pertinent to our pilot
29
30 observations in the focus group study¹³ and also in this pilot epidemiologic study.
31
32
33
34
35
36
37
38

39 Parents with low education levels may lack knowledge and resources about children's sleep
40
41 practices and disabilities, resulting in adverse parenting practices known to affect sleep hygiene
42
43 such as less limit setting, more variability in routines important to establish regular sleep
44
45 patterns, suboptimal configuration of bedrooms to optimize sleep, and inappropriate use of
46
47 electronic devices, and meal timing in relationship to sleep. Better educated parents can have
48
49 more access to information about sleep and disabilities possibly through the internet or group
50
51 membership with other parents of children diagnosed with disabilities. Future research should
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 consider the impact of providing education and support such as sleep hygiene education, as well
7
8 as initiatives to provide social support for parents and families of children with disabilities.
9

10 Although our data suggest that these efforts may especially benefit less well-educated parents, all
11
12 parents may have difficulties in navigating all of the controversies and different claims on the
13
14 internet and may benefit from improved education and support. Our findings of the associations
15
16 documented in our study population, if replicated, could help motivate the development and
17
18 implementation of training programs to increase the parental health literacy (especially sleep
19
20 health literacy). Parents of children with disabilities could benefit from sleep education
21
22 workshops. Social support from families of children with disabilities as well as health care
23
24 providers including occupational and physiotherapists and nurses could also be important in
25
26 helping parents handle with their children's sleep problems.
27
28
29
30
31
32
33

34 Lack of knowledge of healthy sleep behaviors among caregivers has been associated with an
35
36 increased risk of having unhealthy sleep behaviors for their children.⁴¹ Although sleep
37
38 disturbances have been noted to be common in children with neurological conditions (e.g.,
39
40 cerebral palsy), there are no interventions specifically designed to improve sleep in these
41
42 children.⁴² Several small studies of children with ASD have reported that parent-based sleep
43
44 education appears effective in improving child sleep health.^{34, 43} For example, a study of 20
45
46 children with ASD showed that parent-based sleep education workshops improved sleep latency
47
48 from 62.2 minutes to 45.6 minutes.⁴³ Malow et al reported that sleep education to parents of 80
49
50 children with ASD (aged 2-10 years) significantly decreased children's sleep latency from 58.2
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 to 39.6 minutes.³⁴ Our prior qualitative study in Chile indicated that parental knowledge gaps
7
8 regarding healthy sleep behaviors in children support the need for increased sleep health
9
10 education among targeted caregivers.¹³ Pediatricians and family physicians can be trained to
11
12 provide adequate advice and educational messages (e.g., sleep health) to pediatric patients and
13
14 their families.⁴⁴
15
16
17
18
19

20 Our study has several limitations. First, as this was a cross-sectional pilot and feasibility study,
21
22 we did not have a control group of children without disabilities. Second, this study was limited
23
24 by its modest sample size and the heterogeneity of disabilities represented among children
25
26 studied. As such, the confidence intervals were wider for some groups (e.g., the less than high
27
28 school education group) and we were not able to report associations specific to any single
29
30 disability category (e.g., autism). Third, we did not collect information pertaining to some
31
32 aspects of sleep which may be associated with low education levels such as caregivers' shift
33
34 work, sleep hygiene and other factors such as co-sleeping, lack of knowledge about sleep health,
35
36 or inability to obtain medications to treat sleep or conditions in this study. Hence we were not
37
38 able to quantify the influence of these factors on children's sleep patterns. Our findings also
39
40 focused on caregivers (majority were mothers) of children with disabilities in Chile, and may not
41
42 be generalizable to other populations/groups. Although accepted to provide an objective measure
43
44 of sleep-wake cycle, actigraphy has its limitations. For example, periods of quiet wakefulness
45
46 may be interpreted by the device as sleep, and periods of restless sleep may be interpreted by the
47
48 device as wakefulness.^{8, 45} Recent literature has indicated limitations of actigraphy for accurately
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 capturing children's awakenings.⁴⁶ Our study has indicated that children with diseases of the
7
8 musculoskeletal system and connective, skin, and subcutaneous tissue have more awakenings
9
10 because their restless sleep may be represented by actigraphy as awakenings, and/or due to
11
12 medication use or body pain. Despite this, actigraphy has been well validated for objective
13
14 estimation of nighttime sleep parameters across age groups in the natural sleep environment.⁹ As
15
16 this was an exploratory study aimed to examine whether parental education was associated with
17
18 children's sleep disturbances, we did not adjust for multiple comparisons in this study. In
19
20 addition, the simple adjustments for multiple comparisons might be overly conservative because
21
22 many sleep problems (e.g., long WASO and low sleep efficiency) were correlated.
23
24
25
26
27
28

29 CONCLUSIONS

30
31
32
33 These findings indicate that children with disabilities frequently experience difficulties initiating
34
35 sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep
36
37 fragmentation (increased nocturnal awakenings). Among children with disabilities, lower levels
38
39 of caregivers' educational attainment are strongly associated with children's sleep disturbances
40
41 and these associations appear to be independent of children's age, sex, disability group,
42
43 caregiver-child relationship, and caregiver age. Parental support and education programs directed
44
45 to families with low education levels may be of particular importance for sleep behavior
46
47 intervention among children with disabilities. Larger studies are warranted to confirm our
48
49 findings. Future research is also needed regarding the effects of sleep education intervention as
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 well as social support to low educational families of children with disabilities on sleep health,
7
8 with taking into account of different cultural backgrounds.
9

10 11 12 **Contributors' Statement**

13
14 All of the authors have agreed to the content of this manuscript. XC conceptualized and designed
15 the study, supervised data collection, carried the initial analyses, and drafted the initial
16 manuscript. JCV and CB carried out the field survey, supervised data collection, and critically
17 reviewed and revised the manuscript. MP carried out the field survey, coordinated data collection
18 at the study site, and reviewed the manuscript. BG helped develop the study protocol, and
19 critically reviewed and revised the manuscript. SR critically reviewed and revised the
20 manuscript. MAW provided funding support to the study, supervised the study, conceptualized
21 and designed the study, and critically reviewed and revised the manuscript.
22
23
24
25
26
27
28
29
30
31
32
33
34
35

36 **Competing Interests:** The authors have no competing interests to disclose. The authors alone
37 are responsible for the content and writing of the paper.
38
39
40
41
42

43 **Funding Support:** This research was supported by awards from the National Institutes of Health
44 (National Institute on Minority Health and Health Disparities: T37-MD001449), the National
45 Center for Research Resources (NCRR), the National Center for Advancing Translational
46 Sciences (NCATS: 8UL1TR000170-07), and the Rose Traveling Award.
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6 **Ethics Approval:** This study was approved by the institutional review boards of the Centro de
7
8
9 Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health
10
11 Office of Human Research Administration.
12

13 **Data Sharing Statement:** No additional data are available.
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

REFERENCES

1. World report on disability 2011. World Health Organization.
<http://www.who.int/disabilities/>. Accessed October 20, 2014
2. Churchill SS, Kieckhefer GM, Landis CA, Ward TM. Sleep measurement and monitoring in children with Down syndrome: A review of the literature, 1960-2010. *Sleep Med Rev.* 2012;16(5):477-488
3. Sung V, Hiscock H, Sciberras E, Efron D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the child and family. *Arch Pediatr Adolesc Med.* 2008;162(4):336-342
4. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep.* 2001;24(3):303-312
5. Hvolby A, Jorgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med.* 2008;162(4):323-329
6. Allik H, Larsson JO, Smedje H. Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *J Autism Dev Disord.* 2006;36(5):585-595
7. Sekine M, Chen X, Hamanishi S, Wang H, Yamagami T, Kagamimori S. The validity of sleeping hours of healthy young children as reported by their parents. *J Epidemiol.* 2002;12(3):237-242

- 1
2
3
4
5
6 8. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev.*
7
8
9 2002;6(2):113-124
- 10
11 9. Martin JL, Hakim AD. Wrist actigraphy. *Chest.* 2011;139(6):1514-1527
- 12
13 10. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcantara C, et al. Racial/Ethnic
14
15 differences in sleep disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA).
16
17 *Sleep.* 2015;38(6):877-888
- 18
19 11. Mezick EJ, Matthews KA, Hall M, Strollo PJ, Jr., Buysse DJ, Kamarck TW, et al.
20
21 Influence of race and socioeconomic status on sleep: Pittsburgh Sleep SCORE project.
22
23 *Psychosom Med.* 2008;70(4):410-416
- 24
25 12. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter
26
27 sleep in early childhood. *Sleep Med.* 2014;15(5):536-540
- 28
29 13. Chen X, Gelaye B, Velez JC, Pepper M, Gorman S, Barbosa C, et al. Attitudes, beliefs,
30
31 and perceptions of caregivers and rehabilitation providers about disabled children's sleep
32
33 health: a qualitative study. *BMC Pediatr.* 2014;14:245
- 34
35 14. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner HL, Redline S. Effects of
36
37 the home environment on school-aged children's sleep. *Sleep.* 2005;28(11):1419-1427
- 38
39 15. Magana S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services
40
41 among latino children with autism spectrum disorders. *Intellec Dev Disabil.*
42
43 2013;51(3):141-153
- 44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
16. Cameron AJ, van Stralen MM, Brug J, Salmon J, Bere E, Chinapaw MJ, et al. Television in the bedroom and increased body weight: potential explanations for their relationship among European schoolchildren. *Pediatr Obes*. 2013;8(2):130-141
17. Kumar S, Kroon J, Laloo R. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Health Qual Life Outcomes*. 2014;12:41
18. Velez JC, Fitzpatrick AL, Barbosa CI, Diaz M, Urzua M, Andrade AH. Nutritional status and obesity in children and young adults with disabilities in Punta Arenas, Patagonia, Chile. *Int J Rehabil Res*. 2008;31(4):305-313
19. International Classification of Functioning, Disability and Health (ICF). <http://www.who.int/classifications/icf/en/>. Accessed July 16, 2015
20. Chen X, Gelaye B, Velez JC, Barbosa C, Pepper M, Andrade A, et al. Caregivers' hair cortisol: A possible biomarker of chronic stress is associated with obesity measures among children with disabilities. *BMC Pediatr*. 2015;15:9
21. Chen X, Velez JC, Barbosa C, Pepper M, Andrade A, Stoner L, et al. Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress*. 2015;18(1):20-28
22. ActiLife 6. ActiLife, ActiGraph R&D. <http://www.theactigraph.com/products/actisleep/>. Accessed November 12, 2014

- 1
2
3
4
5
6 23. International Classification of Diseases (ICD-10). ICD-10 International Statistical
7 Classification of Diseases and Related Health Problems. 10th Revision. Volume 2.
8 Instruction manual Published 2010
9
10
11
12
13 24. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, et al. Estimating
14 sleep patterns with activity monitoring in children and adolescents: how many nights are
15 necessary for reliable measures? *Sleep*. 1999;22(1):95-103
16
17
18
19
20 25. Adkins KW, Molloy C, Weiss SK, Reynolds A, Goldman SE, Burnette C, et al. Effects of
21 a standardized pamphlet on insomnia in children with autism spectrum disorders.
22 *Pediatrics*. 2012;130 Suppl 2:S139-144
23
24
25
26
27 26. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A
28 systematic review and meta-analysis. *Obesity (Silver Spring)*. 2008;16(2):265-274
29
30
31
32 27. Lipton J, Becker RE, Kothare SV. Insomnia of childhood. *Curr Opin Pediatr*.
33 2008;20(6):641-649
34
35
36
37 28. Malow BA, Byars K, Johnson K, Weiss S, Bernal P, Goldman SE, et al. A practice
38 pathway for the identification, evaluation, and management of insomnia in children and
39 adolescents with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S106-124
40
41
42
43 29. Sumpter RE, Dorris L, Kelly T, McMillan TM. Pediatric sleep difficulties after moderate-
44 severe traumatic brain injury. *J Int Neuropsychol Soc*. 2013;19(7):829-834
45
46
47
48 30. Mahon LV, Lomax M, Grant S, Cross E, Hare DJ, Wraith JE, et al. Assessment of sleep
49 in children with mucopolysaccharidosis type III. *PloS One*. 2014;9(2):e84128
50
51
52
53 31. The National Sleep Foundation. <http://sleepfoundation.org/>. Accessed October 12, 2014
54
55
56
57
58
59
60

- 1
2
3
4
5
6 32. Gibbs S, Wiltshire E, Elder D. Nocturnal sleep measured by actigraphy in children
7
8 witPrader-Willi syndrome. *J Pediatr*. 2013;162(4):765-769
9
10
11 33. Goodlin-Jones BL, Tang K, Liu J, Anders TF. Sleep patterns in preschool-age children
12
13 with autism, developmental delay, and typical development. *J Am Acad Child Adolesc*
14
15 *Psychiatry*. 2008;47(8):930-938
16
17
18 34. Malow BA, Adkins KW, Reynolds A, Weiss SK, Loh A, Fawkes D, et al. Parent-based
19
20 sleep education for children with autism spectrum disorders. *J Autism Dev Disord*.
21
22 2014;44(1):216-228
23
24
25 35. Chamorro R, Algarin C, Garrido M, Causa L, Held C, Lozoff B, et al. Night time sleep
26
27 macrostructure is altered in otherwise healthy 10-year-old overweight children. *Int J*
28
29 *Obes (Lond)*. 2014;38(8):1120-1125
30
31
32 36. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain
33
34 function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc*
35
36 *Health*. 2009;45(4):326-334
37
38
39 37. Cassedy A, Drotar D, Ittenbach R, Hottinger S, Wray J, Wernovsky G, Newburger
40
41 JW, Mahony L, Mussatto K, Cohen MI, Marino BS. The impact of socio-
42
43 economic status on health related quality of life for children and adolescents with heart
44
45 disease. *Health Qual Life Outcomes*. 2013;11:99
46
47
48
49 38. Vathesatogkit P, Batty GD, Woodward M. Socioeconomic disadvantage and disease-
50
51 specific mortality in Asia: systematic review with meta-analysis of population-based
52
53 cohort studies. *J Epidemiol Community Health*. 2014;68(4):375-383
54
55
56
57
58
59
60

- 1
2
3
4
5
6 39. Ebrahim S, Montaner D, Lawlor DA. Clustering of risk factors and social class in
7
8 childhood and adulthood in British women's heart and health study: cross sectional
9
10 analysis. *BMJ*. 2004; 328(7444):861
11
12
13
14 40. Kim J, Son M. The extent and distribution of inequalities in childhood mortality by cause
15
16 of death according to parental socioeconomic positions: a birth cohort study in South
17
18 Korea. *Soc Sci Med*. 2009;69(7):1116-1126
19
20
21
22 41. Owens JA, Jones C, Nash R. Caregivers' knowledge, behavior, and attitudes regarding
23
24 healthy sleep in young children. *J Clin Sleep Med*. 2011;7(4):345-350
25
26
27 42. Galland BC, Elder DE, Taylor BJ. Interventions with a sleep outcome for children with
28
29 cerebral palsy or a post-traumatic brain injury: a systematic review. *Sleep Med Rev*.
30
31 2012;16(6):561-573
32
33
34 43. Reed HE, McGrew SG, Artibee K, Surdkya K, Goldman SE, Frank K, et al. Parent-based
35
36 sleep education workshops in autism. *J Child Neurol*. 2009;24(8):936-945
37
38
39 44. Halal CS, Nunes ML. Education in children's sleep hygiene: which approaches are
40
41 effective? A systematic review. *J Pediatr*. 2014;90(5):449-456
42
43
44 45. Johnson KP, Giannotti F, Cortesi F. Sleep patterns in autism spectrum disorders. *Child*
45
46 *Adolesc Psychiatr Clin N Am*. 2009;18(4):917-928
47
48
49 46. Meltzer LJ, Walsh CM, Traylor J, Westin AM. Direct comparison of two new actigraphs
50
51 and polysomnography in children and adolescents. *Sleep*. 2012;35(1):159-166
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7 **Figure Legends**
8
9

10 **FIGURE 1** Children's Sleep Parameters, by Caregiver Education Levels
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

TABLE 1 Characteristics of Children with Disabilities and Their Primary Caregivers

| | Total (n=125) | Boys (n=69) | Girls (n=56) | P value |
|--------------------------------------|----------------------|----------------------|----------------------|------------|
| Child characteristics | | | | |
| Age (years), mean (SD) | 9.2 (2.2) | 8.8 (2.1) | 9.8 (2.3) | 0.015 |
| Type of disability diagnosis, % | | | | |
| Mental and behavioral disorders | 48.0 | 59.4 | 33.9 | 0.004 |
| Diseases of musculoskeletal system | 16.8 | 10.1 | 25.0 | |
| Diseases of the nervous system | 27.2 | 27.5 | 26.8 | |
| Congenital/chromosomal abnormalities | 8.0 | 2.9 | 14.3 | |
| Daytime napping | 16.8 | 14.5 | 19.6 | 0.444 |
| Medication use | 44.0 | 42.0 | 46.4 | 0.622 |
| Sleep parameters | | | | |
| Sleep onset, median (IQR) | 22:39 (22:06, 23:08) | 22:44 (22:24, 23:08) | 22:33 (21:54, 23:09) | 0.183 |
| Sleep latency, median (IQR), minutes | 27.3 (15.0, 38.9) | 27.1 (14.4, 41.7) | 27.4 (15.4, 38.2) | 0.511 |
| WASO, median (IQR), minutes | 88.1 (65.6, 111.1) | 92.4 (64.4, 112.4) | 81.9 (66.2, 107.0) | 0.411 |

| | | | | |
|---|----------------|----------------|----------------|-------|
| Number of awakening, mean (SD) ^a | 22.1 (6.7) | 22.5 (6.5) | 21.6 (6.9) | 0.441 |
| Awakening length, median (IQR), minutes | 5.1 (4.2, 7.1) | 5.1 (4.2, 7.0) | 5.1 (4.2, 7.1) | 0.923 |
| Sleep duration, median (IQR), hours | 8.0 (7.5, 8.2) | 8.0 (7.3, 8.2) | 8.0 (7.5, 8.3) | 0.459 |
| Sleep efficiency, mean (SD), % ^a | 80.0 (7.2) | 79.0 (8.1) | 81.2 (5.8) | 0.072 |
| Caregiver characteristics | | | | |
| Age (years), mean (SD) | 38.3 (7.8) | 38.5 (7.8) | 38.0 (7.8) | 0.690 |
| Caregiver-child relationship, % | | | | |
| Mother | 88.0 | 88.4 | 87.5 | 0.877 |
| Other | 12.0 | 11.6 | 12.5 | |
| Employed/self-employed | 60.0 | 62.3 | 57.1 | 0.557 |
| Education level, % | | | | |
| <High school | 21.6 | 24.6 | 17.9 | 0.088 |
| High school | 37.6 | 29.0 | 48.2 | |
| >High school | 40.8 | 46.4 | 33.9 | |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

^aOf these sleep parameters, only number of awakening and sleep efficiency were normally distributed (Kolmogorov-Smirnov test: $P > 0.05$). While Student's t-test was used for number of awakening and sleep efficiency, Wilcoxon rank-sum test was used for the other sleep parameters.

For peer review only

TABLE 2 Children's Sleep Parameters, By Caregivers' Education Levels

| Sleep parameters | <High school (n=27) | High school (n=47) | >High school (n=51) | P value |
|--|------------------------|-----------------------|------------------------|------------|
| Sleep onset, median (IQR) | 23:05 (22:17, 23:23) | 22:31 (21:55, 23:04) | 22:39 (22:24, 23:02) | 0.098 |
| Sleep latency, median (IQR), minutes | 35.6 (17.3, 53.7) | 27.1 (17.4, 38.4) | 23.6 (11.1, 35.9) | 0.031 |
| WASO, median (IQR), minutes | 99.1 (88.1, 121.0) | 77.1 (63.4, 103.4) | 77.0 (57.6, 106.0) | 0.006 |
| Number of awakening, mean (SD) ^a | 23.1 (5.7) | 21.2 (6.3) | 22.4 (7.5) | 0.470 |
| Awakening length, median (IQR), minutes | 6.9 (5.0, 9.5) | 5.2 (4.2, 7.2) | 4.7 (3.9, 5.7) | 0.001 |
| Sleep duration, median (IQR), hours | 7.9 (7.3, 8.4) | 8.0 (7.6, 8.2) | 8.0 (7.4, 8.2) | 0.852 |
| Sleep efficiency (%), mean (SD) ^a | 75.9 (7.0) | 80.5 (7.3) | 81.8 (6.5) | 0.002 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

^aSleep efficiency and number of awakening were normally distributed in this study.

TABLE 3 Linear Regression Models for Associations between Caregiver Education and Child Sleep Parameters

| | Number of awakening | | Sleep efficiency (%) | |
|---|-------------------------------|---------|----------------------|---------|
| | Beta (SE) | P value | Beta (SE) | P value |
| <i>Univariate model</i> | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -1.2 (1.3) | 0.384 | -1.3 (1.4) | 0.357 |
| <High school | 0.7 (1.6) | 0.662 | -5.9 (1.7) | <0.001 |
| | <i>P value for trend test</i> | | 0.838 | 0.001 |
| <i>Multivariable model^a</i> | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -0.6 (1.4) | 0.674 | -1.6 (1.4) | 0.269 |
| <High school | 1.9 (1.7) | 0.245 | -6.3 (1.7) | 0.001 |
| | <i>P value for trend test</i> | | 0.364 | <0.001 |
| Abbreviation: SE, standard error. | | | | |

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

1
2
3 ^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36

For peer review only

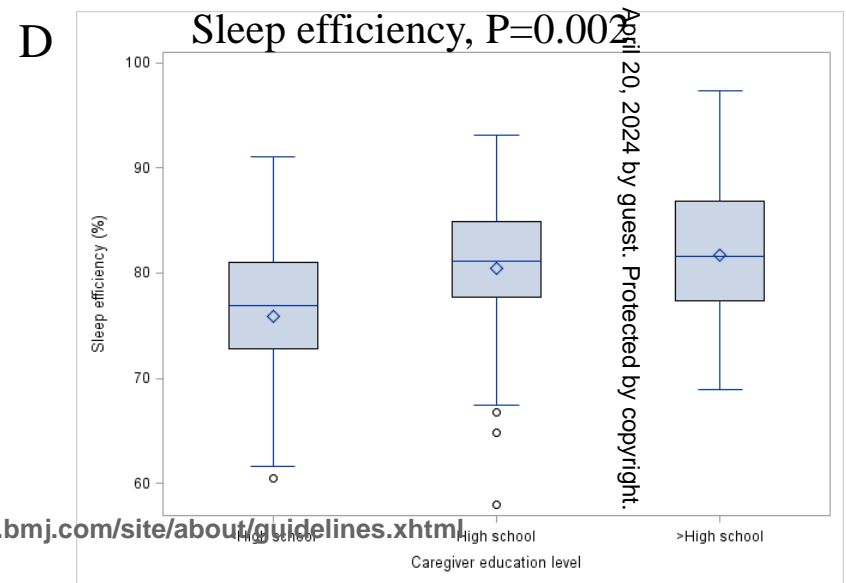
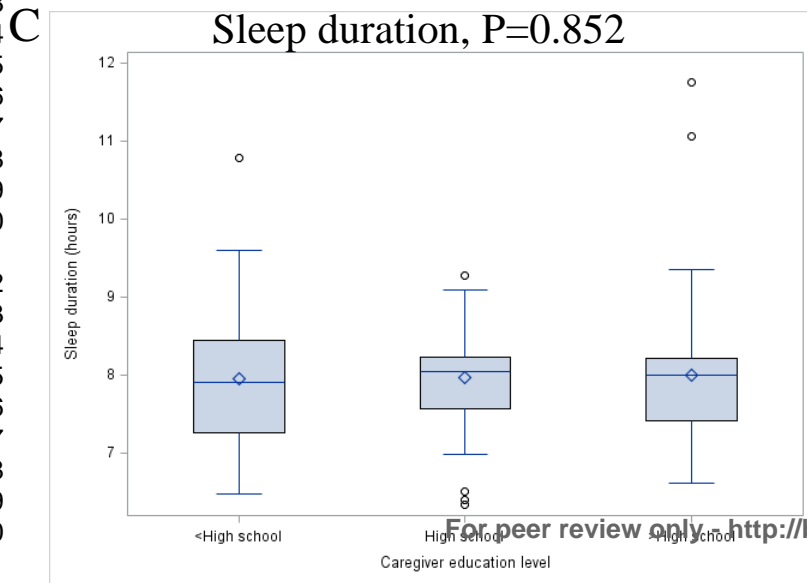
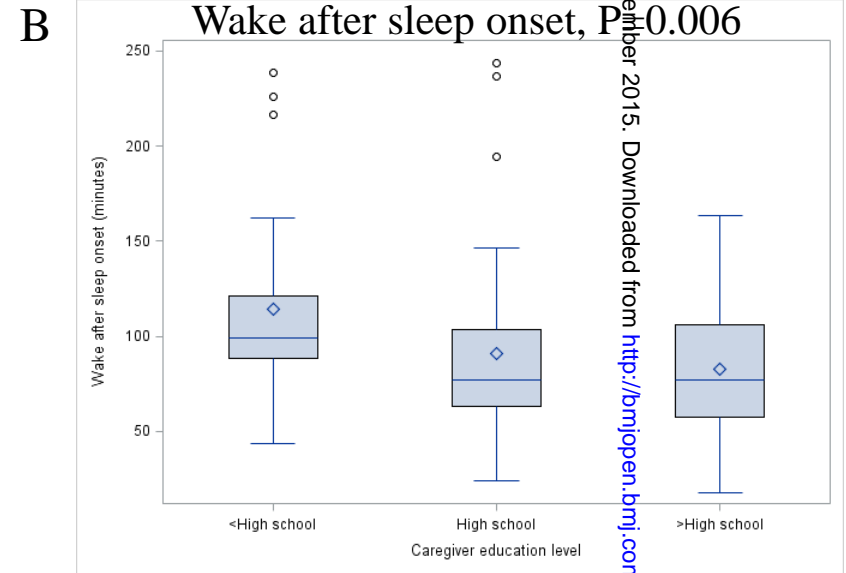
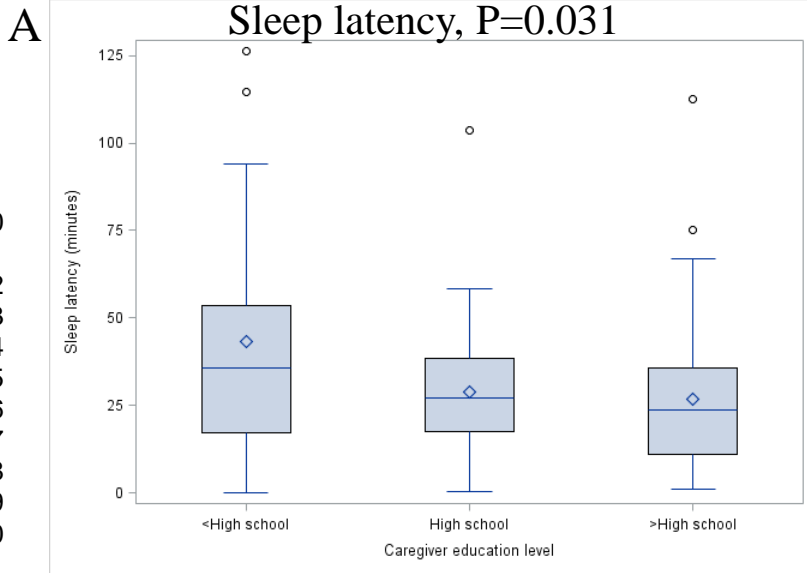
37
38
39 ^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.
40
41
42
43
44
45
46
47
48
49

TABLE 4 Logistic Regression Models for Associations between Caregiver Education and Child Sleep Disturbances

| | Sleep latency ≥ 30 | | Long WASO ≥ 90 | | Sleep duration < 8 | |
|---|-------------------------|--------------|---------------------|--------------|----------------------|--------------|
| | vs. < 30 minutes | | vs. < 90 minutes | | vs. ≥ 8 hours | |
| | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) | P value |
| <i>Univariate model</i> | | | | | | |
| Caregiver education (ref: $>$ high school) | | | | | | |
| High school | 0.95 (0.42, 2.17) | 0.911 | 1.36 (0.61, 3.04) | 0.449 | 0.72 (0.33, 1.60) | 0.424 |
| $<$ High school | 3.37 (1.26, 8.98) | 0.015 | 4.43 (1.58, 12.38) | 0.005 | 0.89 (0.35, 2.25) | 0.797 |
| <i>P value for trend test</i> | | <i>0.029</i> | | <i>0.006</i> | | <i>0.689</i> |
| <i>Multivariable model</i> | | | | | | |
| Caregiver education (ref: $>$ high school) ^a | | | | | | |
| High school | 1.02 (0.42, 2.45) | 0.966 | 1.38 (0.58, 3.30) | 0.468 | 0.70 (0.30, 1.64) | 0.408 |
| $<$ High school | 3.27 (1.12, 9.61) | 0.031 | 5.95 (1.91, 18.53) | 0.002 | 0.78 (0.28, 2.18) | 0.629 |
| <i>P value for trend test</i> | | <i>0.056</i> | | <i>0.004</i> | | <i>0.526</i> |
| Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; WASO, wake after sleep onset. | | | | | | |

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

FIGURE 1 Children's Sleep Parameters, by Caregiver Education Levels



For peer review only. <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

008589 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

Supplementary Table 1 Children's Sleep Parameters, By Types of Disability Diagnosis

| Sleep parameters | Diagnosis I (n=60) | Diagnosis II (n=21) | Diagnosis III (n=34) | Diagnosis IV (n=10) | P value |
|---|-----------------------|------------------------|-------------------------|------------------------|------------|
| Sleep onset, median (IQR) | 22:35 (22:04, 23:03) | 23:05 (22:25, 23:22) | 22:37 (22:19, 23:05) | 22:35 (21:45, 23:03) | 0.187 |
| Sleep latency, median (IQR), minutes | 24.1 (14.7, 40.1) | 28.1 (22.1, 43.0) | 28.8 (14.1, 38.4) | 30.5 (9.1, 39.4) | 0.804 |
| WASO, median (IQR), minutes | 78.4 (63.5, 104.9) | 103.3 (75.0, 123.7) | 89.1 (61.7, 100.0) | 94.0 (69.9, 117.9) | 0.252 |
| Number of awakening, mean (SD) ^a | 22.4 (6.6) | 25.1 (5.1) | 19.3 (6.5) | 23.6 (7.6) | 0.011 |
| Sleep duration, median (IQR), hours | 8.0 (7.7, 8.3) | 7.6 (7.0, 8.0) | 8.0 (7.4, 8.3) | 7.8 (7.1, 8.5) | 0.138 |
| Sleep efficiency, mean (SD), % ^a | 81.2 (6.5) | 78.2 (6.2) | 79.5 (8.6) | 78.3 (8.2) | 0.309 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

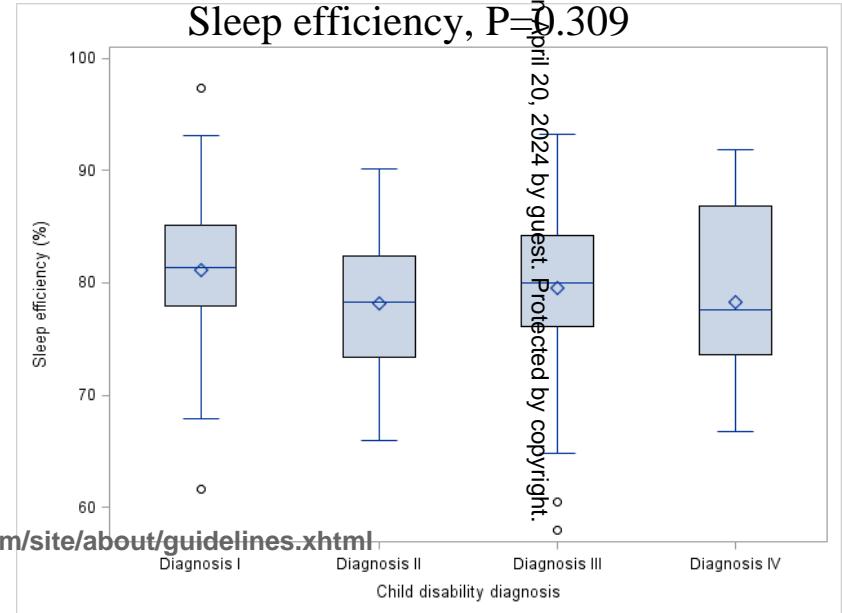
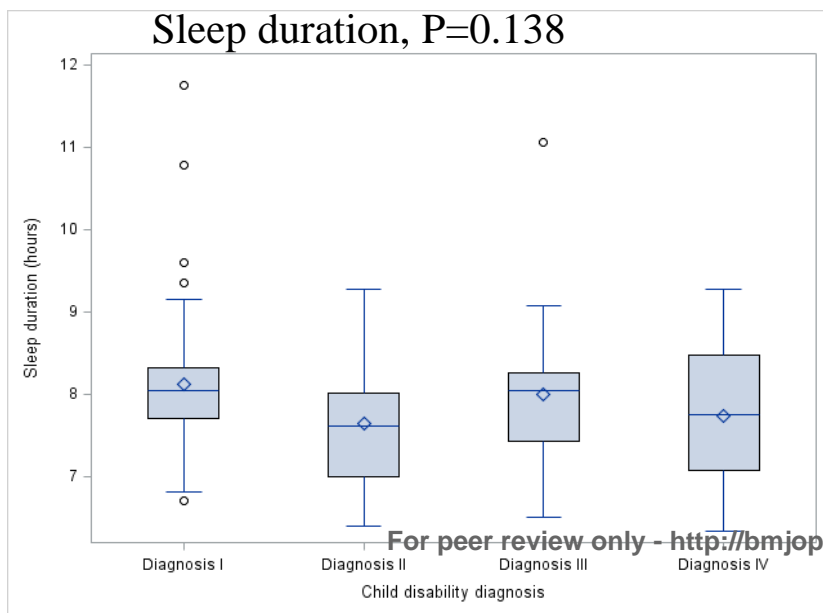
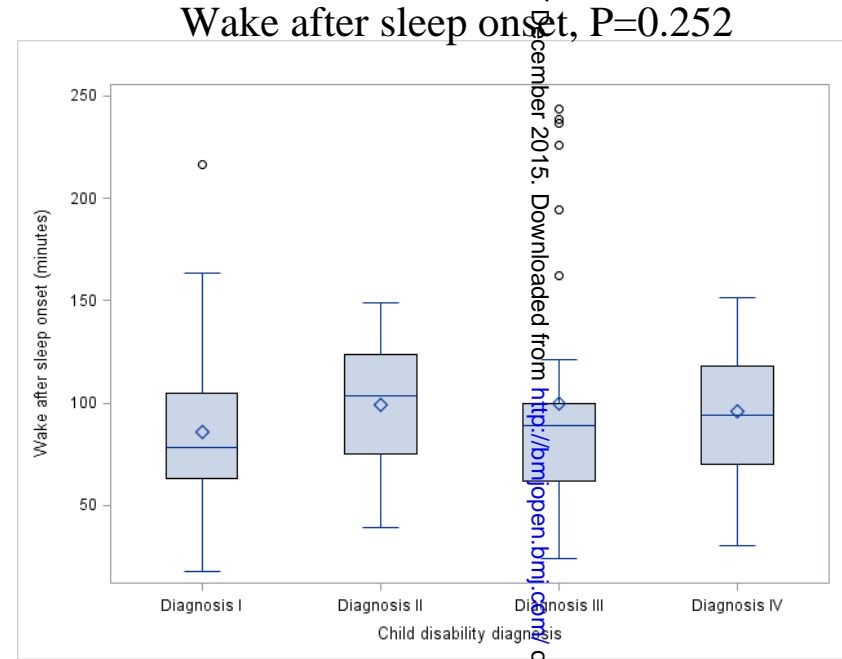
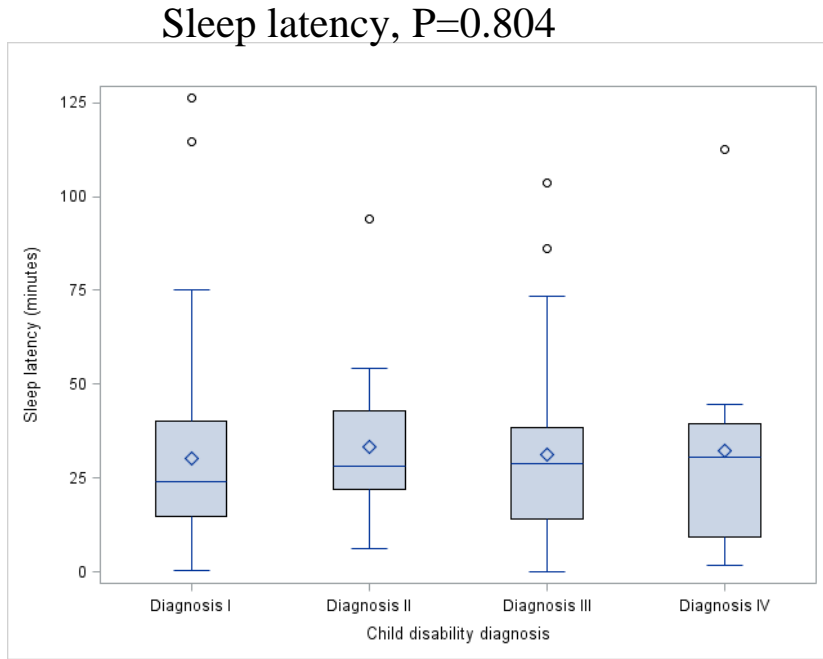
Only sleep efficiency (%) and number of awakening were normally distributed (Kolmogorov-Smirnov test: $P > 0.05$).

^aAnalysis of variance was used for sleep efficiency and number of awakening (normally distributed), while Kruskal-Wallis test was used for other sleep parameters.

Diagnosis I: mental and behavioral disorders (e.g., autism, ADHD, mental retardation); Diagnosis II: diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); Diagnosis III: diseases of the nervous system (e.g., cerebral palsy); Diagnosis IV: congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

SUPPLEMENTARY FIGURE 1 Children's Sleep Parameters, by Disability Group

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42



0-00858959-1
15
7
December 2015. Downloaded from <http://bmjopen.bmj.com/>
on April 20, 2024 by guest. Protected by copyright.

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|------------------------------|---------|---|
| Title and abstract | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including hypotheses |
| Methods | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (a) <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement). |
| Bias | 9 | |
| Study size | 10 | This is a cross-sectional, pilot study. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions |
| Results | | |
| Participants | 13 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| Descriptive data | 14 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| Outcome data | 15 | <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

Discussion

| | | |
|------------------|----|--|
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

Other information

| | | |
|---------|----|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study. |
|---------|----|---|

For peer review only

BMJ Open

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities: The Importance of Caregivers' Educational Attainment Levels

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2015-008589.R2 |
| Article Type: | Research |
| Date Submitted by the Author: | 01-Sep-2015 |
| Complete List of Authors: | Chen, Xiaoli; Harvard T.H. Chan School of Public Health, Department of Epidemiology Velez, Juan Carlos; Centro de Rehabilitación Club de Leones Cruz del Sur, Barbosa, Clarita; Centro de Rehabilitación Club de Leones Cruz del Sur, Pepper, Micah; Centro de Rehabilitación Club de Leones Cruz del Sur, Gelaye, Bizu; Harvard T.H. Chan School of Public Health, Department of Epidemiology Redline, Susan; Brigham and Women's Hospital, Division of Sleep and Circadian Disorders; Harvard Medical School, Department of Medicine Williams, Michelle; Harvard T.H. Chan School of Public Health, Department of Epidemiology |
| Primary Subject Heading: | Paediatrics |
| Secondary Subject Heading: | Public health, Epidemiology |
| Keywords: | SLEEP MEDICINE, Community child health < PAEDIATRICS, PUBLIC HEALTH, EPIDEMIOLOGY |
| | |

SCHOLARONE™
Manuscripts

A Cross-sectional Study of Actigraphy-Measured Sleep Patterns among Children with Disabilities: The Importance of Caregivers' Educational Attainment Levels

Xiaoli Chen, MD, MPH, PhD*¹, Juan Carlos Velez, MD², Clarita Barbosa, MD², Micah Pepper, MPH², Bizu Gelaye, MPH, PhD¹, Susan Redline, MD, MPH^{1,3,4}, Michelle A. Williams, ScD¹

¹Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA 02115, USA

²Centro de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile

³Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston MA 02115

⁴Department of Medicine, Harvard Medical School, Boston, MA 02115, USA

***Address correspondence to:** Xiaoli Chen, MD, MPH, PhD, Department of Epidemiology, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, Phone: 617-432-0067, xchen@hsph.harvard.edu

SHORT TITLE: Sleep patterns among children with disabilities

Abstract: 269 words

Text: 4252 words

Tables: 4; Figures: 1

Supplementary table: 1

Supplementary figure: 1

KEY WORDS

Child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

ABBREVIATIONS

ADHD: attention-deficit/hyperactivity disorder

ASD: autism spectrum disorder

CI: confidence interval

CPASS: Chile Pediatric and Adult Sleep and Stress Study

ICD: International Classification of Diseases

For peer review only
 ICF-CY: International Classification of Functioning, Disability and Health for Children and Youth

IQR: interquartile range
OR: odds ratio
SD: standard deviation
SE: standard error
WASO: wake after sleep onset

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

Abstract

Objectives: To characterize actigraphy-measured sleep patterns among children with disabilities and to examine whether caregivers' education is associated with sleep disturbances.

Design: Cross-sectional study.

Setting: A rehabilitation center in the Patagonia region, Chile.

Methods: This study was conducted among 125 children aged 6-12 years with disabilities (boys: 55.2%) and their primary caregivers in Chile. Children wore ActiSleep monitors for seven days.

A general linear model was fitted to generate least-square means and standard errors (SEs) of sleep efficiency (proportion of the sleep period spent asleep) across caregivers' education levels adjusting for children's age, sex, disability type, caregiver-child relationship, and caregivers' age. Multivariable logistic regression analyses were conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of longer sleep latency (≥ 30 minutes) and longer wake after sleep onset (WASO) (≥ 90 minutes) (a measure of sleep fragmentation) in relation to caregivers' educational attainment.

Results: Median sleep latency was 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours. Mean sleep efficiency was 80.0%. Caregivers' education was positively and significantly associated with children's sleep efficiency ($P_{trend} < 0.001$). Adjusted mean sleep efficiency was 75.7% (SE=1.4) among children of caregivers <high school education, and 81.9% (SE=1.0) among children of caregivers >high school education. Compared to children whose caregivers had >high school, children of caregivers with <high school had higher odds of longer sleep

latency (OR=3.27; 95% CI=1.12-9.61) and longer WASO (OR=5.95; 95% CI=1.91-18.53).

Associations were consistent across disability types.

Conclusions: Children with disabilities experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency). Among children with disabilities, lower level of caregivers' education is associated with more sleep disturbances.

KEY WORDS: child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

Strengths and limitations of this study

- This cross-sectional pilot study is strengthened by its use of actigraphy which has been well validated for objective estimation of nighttime sleep parameters in the natural sleep environment.
- Our study was unique in being the first study to examine the associations between caregivers' education and actigraphy-measured sleep among children with disabilities.
- Its strength also lies in the statistical analysis that was performed using univariate and multivariable linear and logistic regression models.
- This is a cross-sectional, pilot study with a small sample size and high heterogeneity of disabilities included.

INTRODUCTION

1 Approximately 150 million children live with disabilities worldwide.¹ Sleep disturbances,
2 particularly difficulty initiating and maintaining sleep, are commonly reported among children
3 with a wide range of disabilities including Down syndrome, attention-deficit/hyperactivity
4 disorder (ADHD), and autism.²⁻⁶ There are discrepancies between objective measures of sleep
5 and those reported by parents of children with disabilities.⁵ Parents may be unaware of children's
6 sleep disturbances, such as night awakenings, and tend to overestimate their children's sleep
7 duration.⁷ Inferences from prior studies are limited because investigators have relied on parental
8 report of child sleep.³ Although polysomnography is considered the gold standard for measuring
9 sleep, it is burdensome and not easily amenable for use with children who have difficulties
10 sleeping in unfamiliar surroundings. Actigraphy-based sleep offers opportunities to obtain
11 objective measures of sleep in children's typical environment. Actigraphy has been validated for
12 objective measures of sleep in clinical- and population-based studies.^{8,9}

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32 Sleep disturbances have been related to sociodemographic, environmental, and behavioral
33 factors.¹⁰⁻¹³ Children's sleep disturbances have been connected with their home environment that
34 may be influenced by caregivers' characteristics.^{13, 14} Our recent qualitative study showed that
35 while Chilean caregivers and rehabilitation providers recognized the importance of sleep health,
36 they differed in their understanding of how sleep practices influence children's sleep health.¹³

37
38
39
40
41
42
43
44 Parental ability to provide support for healthy behaviors including sleep may be influenced by

45
46 For parental education, a known factor associated with child health measures.^{12, 15-17} Magana et al

1 reported that maternal education and knowledge about autism accounted for differences in the
2 number of specialty services received by Latino children with autism spectrum disorder (ASD)
3 as compared with White children in the US.¹⁵ However, to our knowledge, little research has
4 been conducted regarding the role of caregivers' education in objectively measured sleep among
5 children with disabilities, particularly among Patagonian Chilean children, an understudied
6 population with documented high burden of obesity and related chronic disorders.¹⁸
7
8
9
10
11
12
13
14

15 This cross-sectional pilot study aimed to characterize actigraphy-measured sleep patterns and to
16 examine whether caregivers' education level is associated with sleep disturbances among
17 children with disabilities. We sought to estimate the prevalence of actigraphy-measured sleep
18 disturbances including long sleep latency, long wake after sleep onset (WASO), short sleep
19 duration, and poor sleep quality (low sleep efficiency) among Chilean children with disabilities.
20 Further, following up on results from a previous qualitative study,¹³ we sought to determine the
21 extent to which, if at all, caregivers' low levels of educational attainment are associated with
22 children's sleep disturbances and overall poor sleep quality.
23
24
25
26
27
28
29
30
31
32
33
34
35

36 METHODS

37 Participants

38 The Chile Pediatric and Adult Sleep and Stress Study (CPASS) was a cross-sectional pilot study
39 that was established in September 2012 at the Centro de Rehabilitacion Club de Leones Cruz del
40

41 For peer review only - <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.
42
43
44
45
46
47
48
49

September and December in 2012 among children aged 6-12 years who were receiving routine clinical care for disabilities at the center and their primary caregivers. Children with disabilities in this study were those who had impairments, activity limitations, and participation restrictions due to health conditions such as autism, Down syndrome, and cerebral palsy, according to the World Health Organization, the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY).¹⁹ All children were diagnosed by a clinical care team composed of a pediatric neurologist, a pediatrician with extensive experience in developmental disabilities, and a rehabilitation medicine specialist using diagnostic criteria and/or standardized tests with the input of families and teachers. Primary caregivers were parents, grandparents, relatives, or other adults and were principally responsible for children's well-being and did not have developmental or intellectual disabilities. Research staff talked with caregivers to determine if they could complete the interviewer-administered questionnaire survey. In addition, a physician helped confirm that caregivers had no developmental or intellectual disabilities. Of 153 children whose families were contacted via telephone by research staff, 110 adult caregivers (71.9%) consented to participate in this study. A total of 110 children and caregivers (one caregiver per child) were recruited in the CPASS I. Five children were excluded from this study due to fewer than 3 days of actigraphy data: four children removed monitors after day one or day two of the study; one child lost the monitor on day two. These children had no sleep log data. A total of 105 child-caregiver dyads (95.5% of enrolled families) completed the CPASS I study protocol.

1 The second wave of the CPASS (CPASS II) was conducted among children with disabilities
2 aged 10-21 years and their primary caregivers between April and July in 2013 at the center.^{20, 21}
3
4 Research personnel invited 129 caregivers of children with disabilities to participate. A total of
5
6 90 caregivers (69.8%) agreed to participate in the study. Twenty children were aged 10-12 years
7
8 from the CPASS II. As these two studies (CPASS I and CPASS II) were conducted between
9
10 September 2012 and July 2013 at the same rehabilitation center in Chile, with the same staff and
11
12 with identical study protocols used for assessing sleep traits, we combined the results from the
13
14 two studies in order to have a larger sample size with increased statistical power in the present
15
16 analysis. In total, 125 children aged 6-12 years were included in the current study.
17
18
19
20
21

22 Written informed consents were obtained from primary caregivers of children with disabilities.
23
24 This study was approved by the institutional review boards of the Centro de Rehabilitacion Club
25
26 de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human
27
28 Research Administration.
29
30
31
32
33

34 **Study Procedures**

35
36 A psychologist administered structured questionnaires to caregivers to collect information on
37
38 sociodemographic and lifestyle factors of both children and caregivers. Research staff instructed
39
40 children to wear ActiSleep monitors (ActiLife, ActiGraph R&D, Florida, USA)²² on their non-
41
42 dominant wrists for seven consecutive days. Although the monitors are waterproof, children
43
44

45
46 were instructed to remove them from their wrists before taking showers and/or before swimming.
47
48

Caregivers were also instructed to keep sleep logs of time in bed and time out of bed for their children. Electronic medical records were reviewed by a physician in order to extract children's diagnoses defined by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10).²³

Sleep Parameters

Actigraphic sleep data were collected using the ActiSleep monitors and were analyzed using the ActiLife 6 data analysis software.²² When worn during sleep episodes, the ActiSleep monitor can provide estimates of sleep onset, sleep latency, WASO, number and length of awakenings, sleep duration, and sleep efficiency. Sleep latency is the length of time taken to fall asleep, calculated as the time between "lights off" to the first period of 3 minutes of consecutive epochs scored as sleep. WASO is the number of minutes awake between sleep onset and time of final waking. Sleep efficiency is defined as the proportion of the estimated sleep periods spent asleep. Actigraphy data were collected in 1-min epochs using the zero-crossing modes, and the "Sadeh" sleep algorithm was used for children.²⁴ The majority of children (n=122, 97.6 %) had complete 7-day actigraphic sleep data; two children had 6-day actigraphic data and one child had 3-day data available for study. The averages of sleep parameters were calculated for children who had 3, 6, or 7 days of actigraphic data. There were no missing sleep log data for children included in this study. Caregivers were asked to record their children's sleep logs each morning up awakening and to make sure the sleep logs were complete. Research staff checked children's

sleep logs when caregivers returned with ActiSleep monitors. Information from sleep logs were not used to substitute missing actigraphy data.

Sociodemographic Characteristics and Children's Disabilities

Interviewer-administered questionnaires were used to collect information on children's age, sex, daytime napping, medication use, caregiver-child relationship (e.g., mother), caregivers' age, employment status, and education level. Caregivers were asked to report the highest degree of education they had completed: less than 12th grade (<high school education), high school graduate or equivalent (high school education), some college degree, or college graduate or above (>high school education). According to the ICD-10,²³ children's disabilities were grouped as: 1) mental and behavioral disorders (e.g., ADHD, autism); 2) diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); 3) diseases of the nervous system (e.g., cerebral palsy); and 4) congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

Statistical Analysis

Kolmogorov-Smirnov test was used to assess the normality of sleep parameters. Variables were described using means and standard deviations (SDs) for parametric variables and medians and interquartile ranges (IQRs) for nonparametric variables. Number of nocturnal awakenings and sleep efficiency were normally distributed, whereas sleep onset, sleep latency, WASO,

awakening length, and sleep duration were not normally distributed. Student's t-test was used for

age, number of awakenings, and sleep efficiency as parametric variables by child sex; Wilcoxon rank-sum test was used to test differences in nonparametric variables including sleep onset, sleep latency, WASO, awakening length, and sleep duration by child sex. Fisher's or χ^2 test was conducted to compare differences in sociodemographic factors, daytime napping, medication use, and disability groups by child sex. Analysis of variance or Kruskal-Wallis test was conducted to evaluate the differences in sleep parameters across children's disability groups and caregivers' education levels.

A general linear model was fitted to generate least-square means and standard errors (SEs) of sleep efficiency across caregivers' education levels with adjustment for children's age, sex, disability, caregiver-child relationship, and caregivers' age. Univariate and multivariable linear regression analyses were performed to examine the associations of caregivers' education levels with sleep efficiency and the number of awakenings. Stratified analysis was conducted to evaluate whether the associations between caregivers' education levels and children's sleep disturbances differed according to children's disability groups. Given that we aimed to examine whether children whose caregivers had lower education level were more likely to have sleep disturbances (e.g., long sleep latency, long WASO) and to enhance interpretability, we created categorical variables for these sleep parameters and used in logistic regression models. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using logistic regression models to evaluate the associations of caregivers' educational attainment with children's long sleep

latency (>30 vs ≤ 30 minutes), long WASO (≥ 90 vs < 90 minutes), and short sleep duration (< 8

vs. ≥ 8 hours). These cut points were chosen based on the literature of sleep latency²⁵ and sleep duration,²⁶ as well as sleep data distributions in the study (WASO median=88 minutes, sleep duration median=8 hours; only 9.6% of children had sleep ≥ 9 hours). We also included a variable to represent study wave (I and II) in multivariable regression models and found similar results (data not shown). We conducted sensitivity analysis by including medication use and daytime napping in the models and did not find that they had an impact on our results in this study (data not shown). Statistical significance levels were set at $P < 0.05$ for two-sided analyses. P values were not corrected for multiple testing. All tests were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

The mean age of children with disabilities was 9.2 (SD=2.2; range=6-12) years. Most caregivers were mothers (88.0%); 21.6% of caregivers reported having <high school education level (**Table 1**). There were no statistically significant differences in medication use, daytime napping, caregiver-child relationship, caregivers' age, employment status, or education level between boys and girls.

Median time for sleep onset was 22:39, sleep latency 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours (**Table 1**). The mean number of awakenings was 22.1 and sleep efficiency was 80.0%. There were no statistically significant differences in sleep parameters

between boys and girls (all $P > 0.05$). Overall, 43.2% of children had sleep latency ≥ 30 minutes, 51.2% had short sleep < 8 hours, and 77.6% had low sleep efficiency $< 85\%$.

There were no significant differences in sleep parameters across disability groups

(**Supplementary Figure 1**), except for the number of nocturnal awakenings (**Supplementary**

Table 1). Children with diseases of musculoskeletal system and connective tissue, skin and

subcutaneous tissue appeared to have more awakenings, reflecting more fragmented sleep, than children with other disabilities.

Children whose caregivers had $<$ high school had longer sleep latency, longer WASO, longer

awakening length, and lower sleep efficiency compared to children whose caregivers had $>$ high

school (**Figure 1, Table 2**). Although children of caregivers with $<$ high school tended to have

later sleep onset, higher number of awakenings, and shorter sleep duration when compared to

children of caregivers with higher education, these differences did not reach statistical

significance.

Our general linear model with adjustment for child age, sex, disability group, caregiver-child

relationship, and caregiver age showed that the mean sleep efficiency was the lowest among

children of caregivers with $<$ high school (75.7% [SE=1.4]), followed by children of caregivers

with high school (80.4% [SE=1.0]) and $>$ high school (81.9% [SE=1.0]). Univariate and

multivariable linear regression analyses showed no significant associations between caregivers'

education levels and children's awakening number. However, compared to children whose caregivers had >high school, children of caregivers with <high school had significantly lower sleep efficiency (adjusted $\beta=-6.3$, $SE=1.7$; $P=0.001$) (**Table 3**). Caregivers' educational attainment was positively and significantly associated with children's sleep efficiency in the univariate model ($P_{trend}=0.001$) and the multivariable model ($P_{trend}<0.001$).

As shown in **Table 4** based on logistic regression models, compared to children whose caregivers had >high school, children of caregivers with <high school had higher odds of longer sleep latency ≥ 30 minutes (adjusted $OR=3.27$; 95% $CI=1.12-9.61$) and longer WASO ≥ 90 minutes ($OR=5.95$; 95% $CI=1.91-18.53$). Caregivers' education levels were inversely and significantly associated with children's sleep latency and WASO (both $P_{trend}<0.05$). Children's short sleep duration (<8 hours) was not associated with caregivers' low educational level ($OR=0.78$; 95% $CI=0.28-2.18$).

The associations between caregivers' education and children's sleep efficiency varied little according to disability groups (data not shown in tables). For example, among children with mental and behavioral disorders, children of caregivers with <high school had lower sleep efficiency ($\beta=-6.2$, $SE=2.2$; $P=0.006$), after adjustment for children's age, sex, caregiver-child relationship, and caregivers' age. Similar results were found for children with other disabilities.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

In this cross-sectional pilot study, we assessed sleep patterns using wrist actigraphy over seven consecutive days among Chilean children with disabilities. We found that actigraphy-measured sleep disturbances including long sleep latency (median=27 minutes), long WASO (median=88 minutes), short sleep duration (median=8 hours), high number of nocturnal awakenings (mean=22), and low sleep efficiency (mean=80%) were common among children. These findings indicate that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency), and have increased sleep fragmentation (increased nocturnal awakenings). These indices are common in insomnia, which may occur secondary to chronic health conditions, and for many conditions, is associated with poor quality of life and increased disease-specific health burden including behavioral and cognitive problems.^{27, 28} We also found strong associations between caregivers' low educational attainment and children's sleep disturbances (e.g., low sleep efficiency) independent of children's disability type and other covariates from both children and caregivers. To our knowledge, this is the first study to specifically quantify actigraphy-measured sleep patterns among children with disabilities in relation to caregivers' education levels. Furthermore, we address these questions among Patagonian Chilean children with disabilities, an understudied population in South America.

Children with a wide range of disabilities have been reported to have sleep disturbances, including prolonged sleep latency, increased WASO, short sleep duration, and decreased sleep efficiency in Europe and other developed countries including Canada and New Zealand.^{4-6, 29, 30}

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

For example, in a small study of 8 UK children with mucopolysaccharidosis aged 2-15 years, median actigraphy-measured sleep latency was 35.4 minutes, WASO 83.4 minutes, and sleep efficiency was 75.6%.³⁰ Allik et al reported that children aged 8-12 years with Asperger syndrome and high-functioning autism in Sweden had actigraphy-measured longer sleep latency (mean=32 minutes) and lower sleep efficiency (mean=87%) than controls.⁶ In a study of children aged 5-11 years with ADHD in Denmark, average sleep latency was 26 minutes and 31% of children had sleep latency >30 minutes.⁵ A case-control study using 5 nights of actigraphy for 15 school-aged children with traumatic brain injury and 15 school-aged siblings in the UK reported that brain injury was significantly associated with children's longer sleep latency (mean=50 minutes), longer WASO (mean=65 minutes), and lower sleep efficiency (mean=80%).²⁹ To our knowledge, no research has been conducted on objectively measured sleep parameters in South America (e.g., Chile) among children with disabilities, an understudied sample. In our study of Chilean children with autism and other disabilities, the median of actigraphy-measured sleep latency was 27 minutes, WASO was 88 minutes, and the mean of sleep efficiency was 80%, which were similar to previous research findings.^{5, 29, 30} We also found that a high proportion of Chilean children with disabilities experienced actigraphy-measured sleep disturbances: 43% of children had sleep latency ≥ 30 minutes, 51% had short sleep <8 hours (90% of children had sleep duration <9 hours), and 78% had sleep efficiency <85%. Although school-aged children are recommended to have at least 9 hours of sleep,^{26, 31} in our study, only 10% of Chilean children with disabilities had sleep duration ≥ 9 hours. Gibbs et al reported that among 8 children

aged 4-15 years with Prader-Willi syndrome in New Zealand, median 7-night actigraphy-

measured WASO was 95 minutes.³² **BMJ Open** Corkum et al reported the average of awakenings was 15 among Canadian children with ADHD (aged 7-11 years).⁴ In our current study, the average number of nocturnal awakenings was 22 among Chilean children with ADHD and other disabilities. Our study along with previous research suggests that children with disabilities have difficulties initiating and maintaining good sleep.

Several researchers have reported that children with disabilities have late sleep onset.^{33,34} A study of US children aged 2-5 years with autism and other developmental disabilities reported that the mean of 7-day actigraphy-measured sleep onset time was 21:32.³³ In this study, we found that median sleep onset time was 22:39 among Chilean children with autism and other disabilities. Unique climate (e.g., late sunset) and lifestyle characteristics (e.g., late mealtime) in the Patagonia region may have partly contributed to children's late sleep onset time.^{13,18} Our findings of late sleep onset are generally consistent with literature for children in this age range. For example, a cross-sectional study of 96 healthy Chilean children aged 10 years found that the mean of overnight polysomnography-measured sleep onset time was 23:10 for children with normal weight and 23:20 for children with overweight and obesity.³⁵ Another study of 58 healthy children aged 11-13 years in the US showed that the mean of 4-day actigraphy-measured sleep onset time was 23:27.³⁶ In the Cleveland Children's Sleep and Health Study, 14.8% of US children aged 8-11 years had bedtime 23:00 or later.¹⁴ Future research is warranted to examine potential risk factors of late bedtime such as daytime napping and how to improve sleep onset

1 It has been reported that children whose caregivers have low education levels are more likely to
2 have adverse health outcomes, such as great body weight¹⁶ and poor quality of life.¹⁷ McDonald
3 et al found that lower maternal education was independently associated with parent-reported
4 shorter sleep (<11 hours/night) among young children.¹² Although several studies have reported
5 that parental education is associated with child health,^{12, 15} we are unaware of published reports
6 that have investigated whether and how caregivers' education levels are related to objectively
7 measured sleep problems among children with disabilities. In our study, caregivers' education
8 level in relation to children's sleep disturbances was substantiated through statistically
9 significant association as shown in univariate and multivariable linear and logistic regression
10 models. Our study suggests the importance of tailoring sleep education for caregivers with lower
11 educational attainment to improve children's sleep health. We considered low educational
12 attainment a proxy for low socioeconomic status (SES). It has been reported that educational
13 levels and SES are highly correlated.³⁷ Low SES, as well as low education, has been related to
14 high risk for cardiovascular disease, cancer, and mortality.³⁸ Parental SES has been inversely
15 associated with negative child health outcomes including cardiovascular disease and mortality.^{39,}
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

⁴⁰ Some of the burden from low parental education level may be attributable to relatively lower health literacy, particularly sleep health literacy, which is pertinent to our pilot observations in the focus group study¹³ and also in this pilot epidemiologic study.

1 Parents with low education levels may lack knowledge and resources about children's sleep
2 practices and disabilities, resulting in adverse parenting practices known to affect sleep hygiene
3 such as less limit setting, more variability in routines important to establish regular sleep
4 patterns, suboptimal configuration of bedrooms to optimize sleep, inappropriate use of electronic
5 devices, and meal timing in relationship to sleep. Better-educated parents may have more access
6 to information about sleep and disabilities possibly through the internet or group membership
7 with other parents of children diagnosed with disabilities. Future research should consider the
8 impact of providing education and support such as sleep hygiene education, as well as initiatives
9 to provide social support for parents and families of children with disabilities. Although our data
10 suggest that these efforts may especially benefit less well-educated parents, all parents may have
11 difficulties in navigating all of the controversies and different claims on the internet and may
12 benefit from improved education and support. Our findings of the associations documented in
13 our study population, if replicated, could help motivate the development and implementation of
14 training programs to increase the parental health literacy (especially sleep health literacy).
15 Parents of children with disabilities could benefit from sleep education workshops. Social
16 support from families of children with disabilities as well as health care providers including
17 occupational and physiotherapists and nurses could also be important in helping parents handle
18 with their children's sleep problems.

19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44 Lack of knowledge of healthy sleep behaviors among caregivers has been associated with an

45 increased risk of having unhealthy sleep behaviors for their children.⁴¹ Although sleep
46 For peer review only

1 disturbances have been noted to be common in children with neurological conditions (e.g.,
2 cerebral palsy), there are no interventions specifically designed to improve sleep in these
3 children.⁴² Several small studies of children with ASD have reported that parent-based sleep
4 education appears effective in improving child sleep health.^{34, 43} For example, a study of 20
5 children with ASD showed that parent-based sleep education workshops improved sleep latency
6 from 62.2 minutes to 45.6 minutes.⁴³ Malow et al reported that sleep education to parents of 80
7 children with ASD (aged 2-10 years) significantly decreased children's sleep latency from 58.2
8 to 39.6 minutes.³⁴ Our prior qualitative study in Chile has indicated that parental knowledge gaps
9 regarding healthy sleep behaviors in children support the need for increased sleep health
10 education among targeted caregivers.¹³ Pediatricians and family physicians can be trained to
11 provide adequate advice and educational messages (e.g., sleep health) to pediatric patients and
12 their families.⁴⁴

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30 Our study has several limitations. First, as this was a cross-sectional pilot study that aimed to
31 examine the feasibility of conducting future research with a larger sample size in this
32 underserved population, we did not have a control group of children without disabilities. Second,
33 this study was limited by its modest sample size and the heterogeneity of disabilities represented
34 among children studied. As such, the confidence intervals were wider for some groups (e.g., the
35 less than high school education group) and we were not able to report associations specific to any
36 single disability category (e.g., autism). Third, we did not collect information pertaining to some

37
38
39
40
41
42
43
44
45
46 For aspects of sleep which may be associated with low education levels such as caregivers' shift

work, sleep hygiene, and other factors such as co-sleeping, lack of knowledge about sleep health, or inability to obtain medications to treat sleep or conditions in this study. Hence we were not able to quantify the influence of these factors on children's sleep patterns. Our findings also focused on caregivers (majority were mothers) of children with disabilities in Chile, and may not be generalizable to other populations/groups. Although accepted to provide an objective measure of sleep-wake cycle, actigraphy has its limitations. For example, periods of quiet wakefulness may be interpreted by the device as sleep, and periods of restless sleep may be interpreted by the device as wakefulness.^{8, 45} Recent literature has indicated limitations of actigraphy for accurately capturing children's awakenings.⁴⁶ Our study has indicated that children with diseases of the musculoskeletal system and connective, skin, and subcutaneous tissue have more awakenings because their restless sleep may be represented by actigraphy as awakenings, and/or due to medication use or body pain. Despite this, actigraphy has been well validated for objective estimation of nocturnal sleep parameters across age groups in the natural sleep environment.⁹ As this was an exploratory study that aimed to examine whether parental education was associated with children's sleep disturbances, we did not adjust for multiple comparisons in this study. In addition, the simple adjustments for multiple comparisons might be overly conservative because many sleep problems (e.g., long WASO, low sleep efficiency) were correlated.

CONCLUSIONS

These findings indicate that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

BMJ Open
fragmentation (increased nocturnal awakenings). Among children with disabilities, lower levels of caregivers' educational attainment are strongly associated with children's sleep disturbances and these associations appear to be independent of children's age, sex, disability group, caregiver-child relationship, and caregiver age. Parental support and education programs directed to families with low education levels may be of particular importance for sleep behavior intervention among children with disabilities. Larger studies are warranted to confirm our findings. Future research is also needed regarding the effects of sleep education intervention as well as social support to low educational families of children with disabilities on sleep health, with taking into account of different cultural backgrounds.

Contributors' Statement

All of the authors have agreed to the content of this manuscript. XC conceptualized and designed the study, supervised data collection, carried the initial analyses, and drafted the initial manuscript. JCV and CB carried out the field survey, supervised data collection, and critically reviewed and revised the manuscript. MP carried out the field survey, coordinated data collection at the study site, and reviewed the manuscript. BG helped develop the study protocol, and critically reviewed and revised the manuscript. SR critically reviewed and revised the manuscript. MAW provided funding support to the study, supervised the study, conceptualized and designed the study, and critically reviewed and revised the manuscript.

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

Competing Interests: The authors have no competing interests to disclose. The authors alone are responsible for the content and writing of the paper.

Funding Support: This research was supported by awards from the National Institutes of Health (National Institute on Minority Health and Health Disparities: T37-MD001449), the National Center for Research Resources (NCRR), the National Center for Advancing Translational Sciences (NCATS: 8UL1TR000170-07), and the Rose Traveling Award.

Ethics Approval: This study was approved by the institutional review boards of the Centro de Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human Research Administration.

Data Sharing Statement: No additional data are available.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

REFERENCES

1. World report on disability 2011. World Health Organization.
<http://www.who.int/disabilities/>. Accessed October 20, 2014
2. Churchill SS, Kieckhefer GM, Landis CA, Ward TM. Sleep measurement and monitoring in children with Down syndrome: A review of the literature, 1960-2010. *Sleep Med Rev.* 2012;16(5):477-488
3. Sung V, Hiscock H, Sciberras E, Efron D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the child and family. *Arch Pediatr Adolesc Med.* 2008;162(4):336-342
4. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep.* 2001;24(3):303-312
5. Hvolby A, Jorgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med.* 2008;162(4):323-329
6. Allik H, Larsson JO, Smedje H. Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *J Autism Dev Disord.* 2006;36(5):585-595
7. Sekine M, Chen X, Hamanishi S, Wang H, Yamagami T, Kagamimori S. The validity of sleeping hours of healthy young children as reported by their parents. *J Epidemiol.* 2002;12(3):237-242

8. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev.* 2002;6(2):113-124
9. Martin JL, Hakim AD. Wrist actigraphy. *Chest.* 2011;139(6):1514-1527
10. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcantara C, et al. Racial/Ethnic differences in sleep disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA). *Sleep.* 2015;38(6):877-888
11. Mezick EJ, Matthews KA, Hall M, Strollo PJ, Jr., Buysse DJ, Kamarck TW, et al. Influence of race and socioeconomic status on sleep: Pittsburgh Sleep SCORE project. *Psychosom Med.* 2008;70(4):410-416
12. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter sleep in early childhood. *Sleep Med.* 2014;15(5):536-540
13. Chen X, Gelaye B, Velez JC, Pepper M, Gorman S, Barbosa C, et al. Attitudes, beliefs, and perceptions of caregivers and rehabilitation providers about disabled children's sleep health: a qualitative study. *BMC Pediatr.* 2014;14:245
14. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner HL, Redline S. Effects of the home environment on school-aged children's sleep. *Sleep.* 2005;28(11):1419-1427
15. Magana S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services among latino children with autism spectrum disorders. *Intellec Dev Disabil.* 2013;51(3):141-153

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
16. Cameron AJ, van Stralen MM, Brug J, Salmon J, Bere E, Chinapaw MJ, et al. Television in the bedroom and increased body weight: potential explanations for their relationship among European schoolchildren. *Pediatr Obes*. 2013;8(2):130-141
 17. Kumar S, Kroon J, Laloo R. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Health Qual Life Outcomes*. 2014;12:41
 18. Velez JC, Fitzpatrick AL, Barbosa CI, Diaz M, Urzua M, Andrade AH. Nutritional status and obesity in children and young adults with disabilities in Punta Arenas, Patagonia, Chile. *Int J Rehabil Res*. 2008;31(4):305-313
 19. International Classification of Functioning, Disability and Health (ICF). <http://www.who.int/classifications/icf/en/>. Accessed July 16, 2015
 20. Chen X, Gelaye B, Velez JC, Barbosa C, Pepper M, Andrade A, et al. Caregivers' hair cortisol: A possible biomarker of chronic stress is associated with obesity measures among children with disabilities. *BMC Pediatr*. 2015;15:9
 21. Chen X, Velez JC, Barbosa C, Pepper M, Andrade A, Stoner L, et al. Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress*. 2015;18(1):20-28
 22. ActiLife 6. ActiLife, ActiGraph R&D. <http://www.theactigraph.com/products/actisleep/>. Accessed November 12, 2014

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
23. International Classification of Diseases (ICD-10). ICD-10 International Statistical Classification of Diseases and Related Health Problems. 10th Revision. Volume 2. Instruction manual Published 2010
24. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, et al. Estimating sleep patterns with activity monitoring in children and adolescents: how many nights are necessary for reliable measures? *Sleep*. 1999;22(1):95-103
25. Adkins KW, Molloy C, Weiss SK, Reynolds A, Goldman SE, Burnette C, et al. Effects of a standardized pamphlet on insomnia in children with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S139-144
26. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity (Silver Spring)*. 2008;16(2):265-274
27. Lipton J, Becker RE, Kothare SV. Insomnia of childhood. *Curr Opin Pediatr*. 2008;20(6):641-649
28. Malow BA, Byars K, Johnson K, Weiss S, Bernal P, Goldman SE, et al. A practice pathway for the identification, evaluation, and management of insomnia in children and adolescents with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S106-124
29. Sumpter RE, Dorris L, Kelly T, McMillan TM. Pediatric sleep difficulties after moderate-severe traumatic brain injury. *J Int Neuropsychol Soc*. 2013;19(7):829-834
30. Mahon LV, Lomax M, Grant S, Cross E, Hare DJ, Wraith JE, et al. Assessment of sleep in children with mucopolysaccharidosis type III. *PLoS One*. 2014;9(2):e84128

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
32. Gibbs S, Wiltshire E, Elder D. Nocturnal sleep measured by actigraphy in children with Prader-Willi syndrome. *J Pediatr.* 2013;162(4):765-769
 33. Goodlin-Jones BL, Tang K, Liu J, Anders TF. Sleep patterns in preschool-age children with autism, developmental delay, and typical development. *J Am Acad Child Adolesc Psychiatry.* 2008;47(8):930-938
 34. Malow BA, Adkins KW, Reynolds A, Weiss SK, Loh A, Fawkes D, et al. Parent-based sleep education for children with autism spectrum disorders. *J Autism Dev Disord.* 2014;44(1):216-228
 35. Chamorro R, Algarin C, Garrido M, Causa L, Held C, Lozoff B, et al. Night time sleep macrostructure is altered in otherwise healthy 10-year-old overweight children. *Int J Obes (Lond).* 2014;38(8):1120-1125
 36. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc Health.* 2009;45(4):326-334
 37. Cassidy A, Drotar D, Ittenbach R, Hottinger S, Wray J, Wernovsky G, Newburger JW, Mahony L, Mussatto K, Cohen MI, Marino BS. The impact of socioeconomic status on health related quality of life for children and adolescents with heart disease. *Health Qual Life Outcomes.* 2013;11:99
 38. Vathesatogkit P, Batty GD, Woodward M. Socioeconomic disadvantage and disease-specific mortality in Asia: systematic review with meta-analysis of population-based

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
39. Ebrahim S, Montaner D, Lawlor DA. Clustering of risk factors and social class in childhood and adulthood in British women's heart and health study: cross sectional analysis. *BMJ*. 2004; 328(7444):861
40. Kim J, Son M. The extent and distribution of inequalities in childhood mortality by cause of death according to parental socioeconomic positions: a birth cohort study in South Korea. *Soc Sci Med*. 2009;69(7):1116-1126
41. Owens JA, Jones C, Nash R. Caregivers' knowledge, behavior, and attitudes regarding healthy sleep in young children. *J Clin Sleep Med*. 2011;7(4):345-350
42. Galland BC, Elder DE, Taylor BJ. Interventions with a sleep outcome for children with cerebral palsy or a post-traumatic brain injury: a systematic review. *Sleep Med Rev*. 2012;16(6):561-573
43. Reed HE, McGrew SG, Artibee K, Surdkya K, Goldman SE, Frank K, et al. Parent-based sleep education workshops in autism. *J Child Neurol*. 2009;24(8):936-945
44. Halal CS, Nunes ML. Education in children's sleep hygiene: which approaches are effective? A systematic review. *J Pediatr*. 2014;90(5):449-456
45. Johnson KP, Giannotti F, Cortesi F. Sleep patterns in autism spectrum disorders. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):917-928
46. Meltzer LJ, Walsh CM, Traylor J, Westin AM. Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep*. 2012;35(1):159-166

Figure Legends

Figure 1 Children’s Sleep Parameters, by Caregiver Education Levels

For peer review only

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**Table 1** Characteristics of Children with Disabilities and Their Primary Caregivers

| | Total | Boys | Girls |
|--------------------------------------|----------------------|----------------------|----------------------|
| | (n=125) | (n=69) | (n=56) |
| Child characteristics | | | |
| Age, mean (SD), years | 9.2 (2.2) | 8.8 (2.1) | 9.8 (2.3) |
| Type of disability diagnosis, % | | | |
| Mental and behavioral disorders | 48.0 | 59.4 | 33.9 |
| Diseases of musculoskeletal system | 16.8 | 10.1 | 25.0 |
| Diseases of the nervous system | 27.2 | 27.5 | 26.8 |
| Congenital/chromosomal abnormalities | 8.0 | 2.9 | 14.3 |
| Daytime napping | 16.8 | 14.5 | 19.6 |
| Medication use | 44.0 | 42.0 | 46.4 |
| Sleep parameters | | | |
| Sleep onset, median (IQR) | 22:39 (22:06, 23:08) | 22:44 (22:24, 23:08) | 22:33 (21:54, 23:09) |
| Sleep latency, median (IQR), minutes | 27.3 (15.0, 38.9) | 27.1 (14.4, 41.7) | 27.4 (15.4, 38.9) |
| WASO, median (IQR), minutes | 88.1 (65.6, 111.1) | 92.4 (64.4, 112.4) | 81.9 (66.2, 107.0) |

BMJ Open: first published as 10.1136/bmjopen-2015-008589 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

| | | | | |
|----|--|----------------|----------------|----------------|
| 1 | | | | |
| 2 | | | | |
| 3 | Number of awakenings, mean (SD) ^a | 22.1 (6.7) | 22.5 (6.5) | 21.6 (6.9) |
| 4 | | | | |
| 5 | Awakening length, median (IQR), minutes | 5.1 (4.2, 7.1) | 5.1 (4.2, 7.0) | 5.1 (4.2, 7.1) |
| 6 | | | | |
| 7 | Sleep duration, median (IQR), hours | 8.0 (7.5, 8.2) | 8.0 (7.3, 8.2) | 8.0 (7.5, 8.3) |
| 8 | | | | |
| 9 | Sleep efficiency, mean (SD), % ^a | 80.0 (7.2) | 79.0 (8.1) | 81.2 (5.8) |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | Caregiver characteristics | | | |
| 14 | | | | |
| 15 | Age, mean (SD), years | 38.3 (7.8) | 38.5 (7.8) | 38.0 (7.8) |
| 16 | | | | |
| 17 | Caregiver-child relationship, % | | | |
| 18 | | | | |
| 19 | Mother | 88.0 | 88.4 | 87.5 |
| 20 | | | | |
| 21 | Other | 12.0 | 11.6 | 12.5 |
| 22 | | | | |
| 23 | Employed/self-employed | 60.0 | 62.3 | 57.1 |
| 24 | | | | |
| 25 | Education level, % | | | |
| 26 | | | | |
| 27 | <High school | 21.6 | 24.6 | 17.9 |
| 28 | | | | |
| 29 | High school | 37.6 | 29.0 | 48.2 |
| 30 | | | | |
| 31 | >High school | 40.8 | 46.4 | 33.9 |
| 32 | | | | |
| 33 | | | | |
| 34 | | | | |
| 35 | | | | |

36 Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Of these sleep parameters, only number of awakenings and sleep efficiency were normally distributed (Kolmogorov-Smirnov test: $P > 0.05$). While Student's t-test was used for number of awakenings and sleep efficiency, Wilcoxon rank-sum test was used for the other sleep parameters.

For peer review only

1
2
3 **Table 2** Children's Sleep Parameters, By Caregivers' Education Levels
4

| 5 | <High school | High school | >High school |
|---|----------------------|----------------------|----------------------|
| 6 Sleep parameters | (n=27) | (n=47) | (n=51) |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 Sleep onset, median (IQR) | 23:05 (22:17, 23:23) | 22:31 (21:55, 23:04) | 22:39 (22:24, 23:02) |
| 12 | | | |
| 13 Sleep latency, median (IQR), minutes | 35.6 (17.3, 53.7) | 27.1 (17.4, 38.4) | 23.6 (11.1, 35.9) |
| 14 | | | |
| 15 WASO, median (IQR), minutes | 99.1 (88.1, 121.0) | 77.1 (63.4, 103.4) | 77.0 (57.6, 106.0) |
| 16 | | | |
| 17 | | | |
| 18 Number of awakenings, mean (SD) ^a | 23.1 (5.7) | 21.2 (6.3) | 22.4 (7.5) |
| 19 | | | |
| 20 Awakening length, median (IQR), minutes | 6.9 (5.0, 9.5) | 5.2 (4.2, 7.2) | 4.7 (3.9, 5.7) |
| 21 | | | |
| 22 Sleep duration, median (IQR), hours | 7.9 (7.3, 8.4) | 8.0 (7.6, 8.2) | 8.0 (7.4, 8.2) |
| 23 | | | |
| 24 | | | |
| 25 Sleep efficiency, mean (SD), % ^a | 75.9 (7.0) | 80.5 (7.3) | 81.8 (6.5) |
| 26 | | | |
| 27 | | | |

28 Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

29
30 Sleep efficiency and number of awakenings were normally distributed in this study.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**Table 3** Linear Regression Models for Associations between Caregiver Education and Child Sleep Parameters

| | Number of awakenings | | Sleep efficiency (%) | |
|---|----------------------|--------------|----------------------|------------------|
| | Beta (SE) | P value | Beta (SE) | P value |
| Univariate model | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -1.2 (1.3) | 0.384 | -1.3 (1.4) | 0.357 |
| <High school | 0.7 (1.6) | 0.662 | -5.9 (1.7) | <0.001 |
| <i>P value for trend test</i> | | <i>0.838</i> | | <i>0.001</i> |
| Multivariable model^a | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -0.6 (1.4) | 0.674 | -1.6 (1.4) | 0.269 |
| <High school | 1.9 (1.7) | 0.245 | -6.3 (1.7) | 0.001 |
| <i>P value for trend test</i> | | <i>0.364</i> | | <i><0.001</i> |

Abbreviation: SE, standard error.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

Table 4 Logistic Regression Models for Associations between Caregiver Education and Child Sleep Disturbances

| | Sleep latency ≥ 30 | | WASO ≥ 90 | | Sleep duration |
|--|-------------------------|---------|--------------------|---------|------------------|
| | vs. <30 minutes | | vs. <90 minutes | | vs. <8 |
| | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) |
| Univariate model | | | | | |
| Caregiver education (ref: >high school) | | | | | |
| High school | 0.95 (0.42, 2.17) | 0.911 | 1.36 (0.61, 3.04) | 0.449 | 0.72 (0.33, 1.6) |
| <High school | 3.37 (1.26, 8.98) | 0.015 | 4.43 (1.58, 12.38) | 0.005 | 0.89 (0.35, 2.2) |
| <i>P value for trend test</i> | | 0.029 | | 0.006 | |
| Multivariable model | | | | | |
| Caregiver education (ref: >high school) ^a | | | | | |
| High school | 1.02 (0.42, 2.45) | 0.966 | 1.38 (0.58, 3.30) | 0.468 | 0.70 (0.30, 1.6) |
| <High school | 3.27 (1.12, 9.61) | 0.031 | 5.95 (1.91, 18.53) | 0.002 | 0.78 (0.28, 2.1) |
| <i>P value for trend test</i> | | 0.056 | | 0.004 | |

Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; WASO, wake after sleep onset.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

BMJ Open: first published as 10.1136/bmjopen-2015-008589 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 1 Children’s Sleep Parameters, by Caregiver Education Levels (HS: high school)

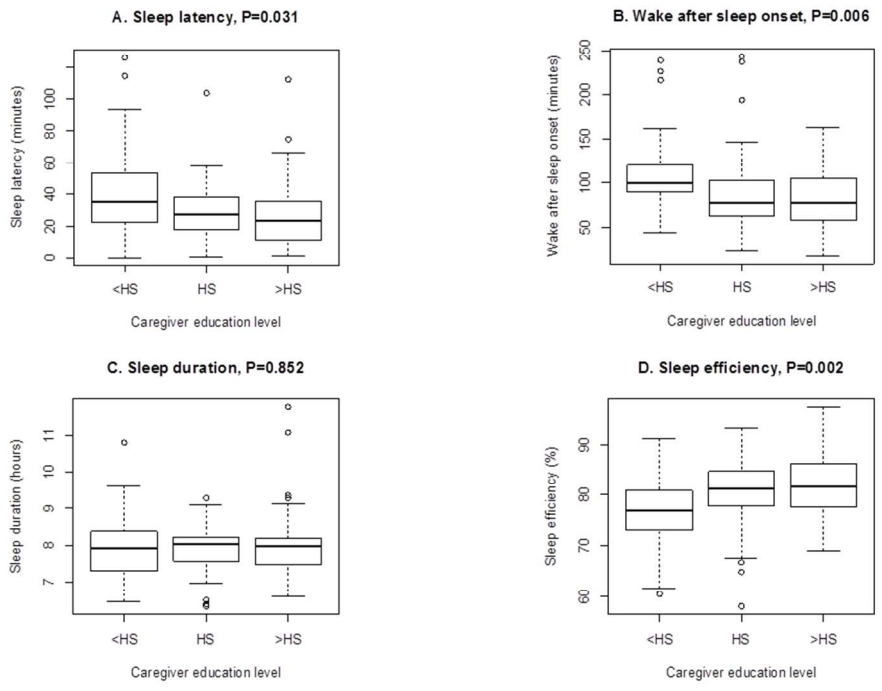


Figure in TIFF format
254x190mm (96 x 96 DPI)

Review only

Supplementary Table 1 Children's Sleep Parameters, By Types of Disability Diagnoses

| Sleep parameters | Diagnosis I (n=60) | Diagnosis II (n=21) | Diagnosis III (n=34) | Diagnosis IV (n=10) | P value |
|--|-----------------------|------------------------|-------------------------|------------------------|------------|
| Sleep onset, median (IQR) | 22:35 (22:04, 23:03) | 23:05 (22:25, 23:22) | 22:37 (22:19, 23:05) | 22:35 (21:45, 23:03) | 0.187 |
| Sleep latency, median (IQR), minutes | 24.1 (14.7, 40.1) | 28.1 (22.1, 43.0) | 28.8 (14.1, 38.4) | 30.5 (9.1, 39.4) | 0.804 |
| WASO, median (IQR), minutes | 78.4 (63.5, 104.9) | 103.3 (75.0, 123.7) | 89.1 (61.7, 100.0) | 94.0 (69.9, 117.9) | 0.252 |
| Number of awakenings, mean (SD) ^a | 22.4 (6.6) | 25.1 (5.1) | 19.3 (6.5) | 23.6 (7.6) | 0.011 |
| Sleep duration, median (IQR), hours | 8.0 (7.7, 8.3) | 7.6 (7.0, 8.0) | 8.0 (7.4, 8.3) | 8 (7.1, 8.5) | 0.138 |
| Sleep efficiency, mean (SD), % ^a | 81.2 (6.5) | 78.2 (6.2) | 79.5 (8.6) | 78.3 (8.2) | 0.309 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

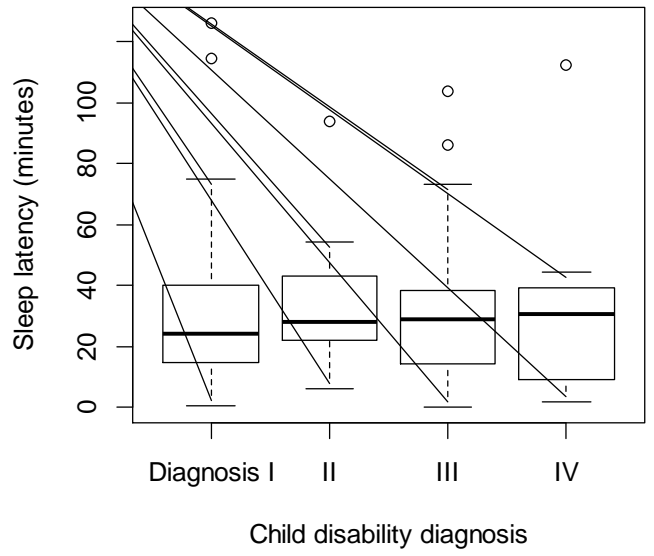
Only sleep efficiency (%) and number of awakenings were normally distributed (Kolmogorov-Smirnov test: $p > 0.05$).

^aAnalysis of variance was used for sleep efficiency and number of awakenings (normally distributed), while Kruskal-Wallis test was used for other sleep parameters.

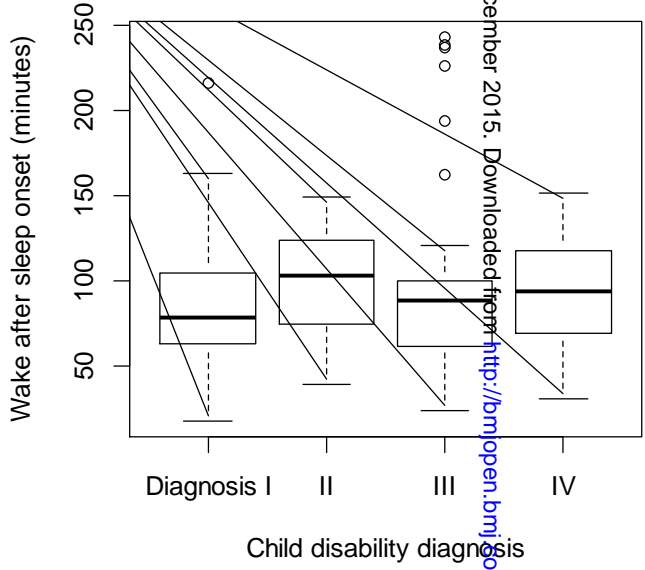
Diagnosis I: mental and behavioral disorders (e.g., autism, ADHD, mental retardation); Diagnosis II: disease of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); Diagnosis III: diseases of the nervous system (e.g., cerebral palsy); Diagnosis IV: congenital malformations, deformations and chromosomal abnormalities (e.g. Down syndrome).

Supplementary Figure 1 Children's Sleep Parameters, by Disability Diagnoses

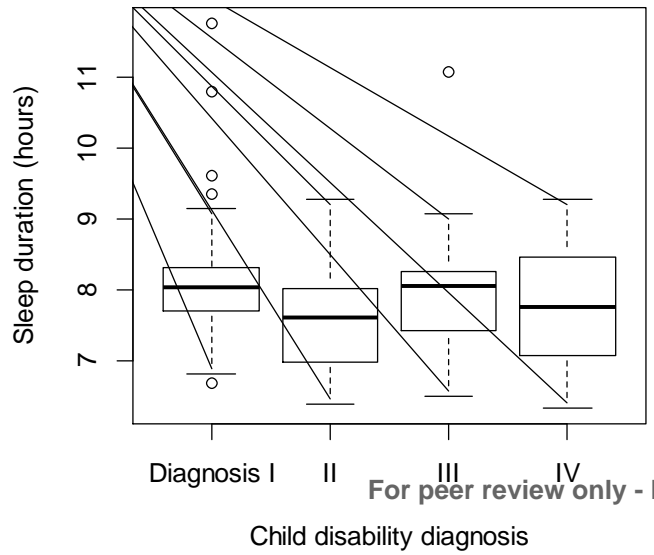
A. Sleep latency, P=0.804



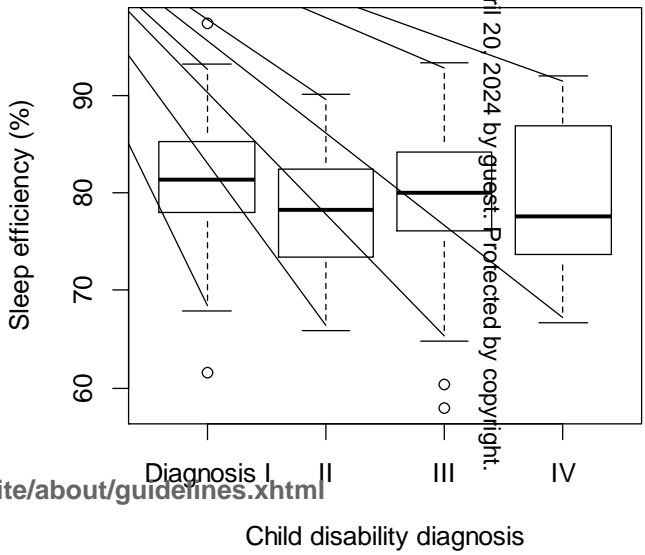
B. Wake after sleep onset, P=0.252



C. Sleep duration, P=0.138



D. Sleep efficiency, P=0.309



0-0855 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> by guest. Protected by copyright.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|------------------------------|---------|---|
| Title and abstract | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including hypotheses |
| Methods | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (a) <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement). |
| Bias | 9 | |
| Study size | 10 | This is a cross-sectional, pilot study. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions |
| Results | | |
| Participants | 13 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| Descriptive data | 14 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| Outcome data | 15 | <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

Discussion

| | | |
|------------------|----|--|
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

Other information

| | | |
|---------|----|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study. |
|---------|----|---|

For peer review only

BMJ Open

Evaluation of Actigraphy-Measured Sleep Patterns among Children with Disabilities and Associations with Caregivers' Educational Attainment: Results from a Cross-Sectional Pilot Study

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2015-008589.R3 |
| Article Type: | Research |
| Date Submitted by the Author: | 15-Sep-2015 |
| Complete List of Authors: | Chen, Xiaoli; Harvard T.H. Chan School of Public Health, Department of Epidemiology Velez, Juan Carlos; Centro de Rehabilitación Club de Leones Cruz del Sur, Barbosa, Clarita; Centro de Rehabilitación Club de Leones Cruz del Sur, Pepper, Micah; Centro de Rehabilitación Club de Leones Cruz del Sur, Gelaye, Bizu; Harvard T.H. Chan School of Public Health, Department of Epidemiology Redline, Susan; Brigham and Women's Hospital, Division of Sleep and Circadian Disorders; Harvard Medical School, Department of Medicine Williams, Michelle; Harvard T.H. Chan School of Public Health, Department of Epidemiology |
| Primary Subject Heading: | Paediatrics |
| Secondary Subject Heading: | Public health, Epidemiology |
| Keywords: | SLEEP MEDICINE, Community child health < PAEDIATRICS, PUBLIC HEALTH, EPIDEMIOLOGY |
| | |

SCHOLARONE™
Manuscripts

BMJ Open
Evaluation of Actigraphy-Measured Sleep Patterns among Children with Disabilities and Associations with Caregivers' Educational Attainment: Results from a Cross-Sectional Pilot Study

Xiaoli Chen, MD, MPH, PhD*¹, Juan Carlos Velez, MD², Clarita Barbosa, MD², Micah Pepper, MPH², Bizu Gelaye, MPH, PhD¹, Susan Redline, MD, MPH^{1,3,4}, Michelle A. Williams, ScD¹

¹Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA 02115, USA

²Centro de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile

³Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston MA 02115

⁴Department of Medicine, Harvard Medical School, Boston, MA 02115, USA

***Address correspondence to:** Xiaoli Chen, MD, MPH, PhD, Department of Epidemiology, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, Phone: 617-432-0067, xchen@hsph.harvard.edu

SHORT TITLE: Sleep patterns among children with disabilities

Abstract: 291 words

Text: 4,472 words

Tables: 4; Figures: 1

Supplementary table: 1

Supplementary figure: 1

KEY WORDS

Child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

ABBREVIATIONS

ADHD: attention-deficit/hyperactivity disorder

ASD: autism spectrum disorder

CI: confidence interval

CPASS: Chile Pediatric and Adult Sleep and Stress Study

ICD: International Classification of Diseases

For peer review only
 ICF-CY: International Classification of Functioning, Disability and Health for Children and Youth

IQR: interquartile range
 OR: odds ratio
 SD: standard deviation
 SE: standard error
 WASO: wake after sleep onset

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

For peer review only

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

Abstract

Objectives: To test the feasibility of using wrist-actigraphy to collect objective measures of sleep and to characterize actigraphy-measured sleep patterns among children with disabilities. We also assessed the extent to which, if at all, caregivers' education is associated with children's sleep disturbances.

Design: Cross-sectional pilot study.

Setting: A rehabilitation center in the Patagonia region, Chile.

Methods: This study was conducted among 125 children aged 6-12 years with disabilities (boys: 55.2%) and their primary caregivers in Chile. Children wore ActiSleep monitors for seven days. A general linear model was fitted to generate least-square means and standard errors (SEs) of sleep efficiency (proportion of the sleep period spent asleep) across caregivers' education levels adjusting for children's age, sex, disability type, caregiver-child relationship, and caregivers' age. Multivariable logistic regression analyses were conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of longer sleep latency (≥ 30 minutes) and longer wake after sleep onset (WASO) (≥ 90 minutes) (a measure of sleep fragmentation) in relation to caregivers' educational attainment.

Results: Median sleep latency was 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours. Mean sleep efficiency was 80.0%. Caregivers' education was positively and significantly associated with children's sleep efficiency ($P_{trend} < 0.001$). Adjusted mean sleep efficiency was 75.7% (SE=1.4) among children of caregivers <high school education, and 81.9% (SE=1.0)

among children of caregivers >high school education. Compared to children whose caregivers

had >high school, children of caregivers with <high school had higher odds of longer sleep latency (OR=3.27; 95% CI=1.12-9.61) and longer WASO (OR=5.95; 95% CI=1.91-18.53).

Associations were consistent across disability types.

Conclusions: Children with disabilities experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency). Among children with disabilities, lower level of caregivers' education is associated with more sleep disturbances.

KEY WORDS: child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

Strengths and limitations of this study

- This cross-sectional pilot study is strengthened by its use of wrist-actigraphy which has been well validated for objective estimation of nighttime sleep parameters in the natural sleep environment.
- Our study was unique in being the first study to examine the associations between caregivers' education and actigraphy-measured sleep among children with disabilities.
- Its strength also lies in the statistical analysis that was performed using univariate and multivariable linear and logistic regression models.
- This is a cross-sectional, pilot study with a small sample size and high heterogeneity of disabilities included.

INTRODUCTION

1 Approximately 150 million children live with disabilities worldwide.¹ Sleep disturbances,
2 particularly difficulty initiating and maintaining sleep, are commonly reported among children
3 with a wide range of disabilities including Down syndrome, attention-deficit/hyperactivity
4 disorder (ADHD), and autism.²⁻⁶ There are discrepancies between objective measures of sleep
5 and those reported by parents of children with disabilities.⁵ Parents may be unaware of children's
6 sleep disturbances, such as night awakenings, and tend to overestimate their children's sleep
7 duration.⁷ Inferences from prior studies are limited because investigators have relied on parental
8 report of child sleep.³ Although polysomnography is considered the gold standard for measuring
9 sleep, it is burdensome and not easily amenable for use with children who have difficulties
10 sleeping in unfamiliar surroundings. Actigraphy-based sleep offers opportunities to obtain
11 objective measures of sleep in children's typical environment. Actigraphy has been validated for
12 objective measures of sleep in clinical- and population-based studies.^{8,9}

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32 Sleep disturbances have been related to sociodemographic, environmental, and behavioral
33 factors.¹⁰⁻¹³ Children's sleep disturbances have been connected with their home environment that
34 may be influenced by caregivers' characteristics.^{13, 14} Our recent qualitative study showed that
35 while Chilean caregivers and rehabilitation providers recognized the importance of sleep health,
36 they differed in their understanding of how sleep practices influence children's sleep health.¹³

37
38
39
40
41
42
43
44 Parental ability to provide support for healthy behaviors including sleep may be influenced by

45
46 For parental education, a known factor associated with child health measures.^{12, 15-17} Magana et al

1 reported that maternal education and knowledge about autism accounted for differences in the
2 number of specialty services received by Latino children with autism spectrum disorder (ASD)
3 as compared with White children in the US.¹⁵ However, to our knowledge, little research has
4 been conducted regarding the role of caregivers' education in objectively measured sleep among
5 children with disabilities, particularly among Patagonian Chilean children, an understudied
6 population with documented high burden of obesity and related chronic disorders.¹⁸
7
8
9
10
11
12
13
14

15 This cross-sectional pilot study was designed to examine the feasibility of conducting future
16 research using wrist-actigraphy as a means for collecting objective measures of sleep patterns
17 among children with disabilities. Our primary objective for designing and conducting this pilot
18 study was to document the feasibility of using this data collection approach in a relatively
19 understudied population, and to use the information to design a larger study in this population.
20 Using collected data from this pilot study, we also sought to characterize actigraphy-measured
21 sleep patterns and to examine whether caregivers' education level is associated with sleep
22 disturbances among children with disabilities. Specifically, we sought to estimate the prevalence
23 of actigraphy-measured sleep disturbances including long sleep latency, long wake after sleep
24 onset (WASO), short sleep duration, and poor sleep quality (low sleep efficiency) among
25 Chilean children with disabilities. Further, following up on results from a previous qualitative
26 study,¹³ we sought to determine the extent to which, if at all, caregivers' low levels of
27 educational attainment are associated with children's sleep disturbances and overall poor sleep
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45

1 and teachers. Primary caregivers were parents, grandparents, relatives, or other adults and were
2 principally responsible for children's well-being and did not have developmental or intellectual
3 disabilities. Research staff talked with caregivers to determine if they could complete the
4 interviewer-administered questionnaire survey. In addition, a physician helped confirm that
5 caregivers had no developmental or intellectual disabilities. Of 153 children whose families were
6 contacted via telephone by research staff, 110 adult caregivers (71.9%) consented to participate
7 in this study. A total of 110 children and caregivers (one caregiver per child) were recruited in
8 the CPASS I. Five children were excluded from this study due to fewer than 3 days of actigraphy
9 data: four children removed monitors after day one or day two of the study; one child lost the
10 monitor on day two. These children had no sleep log data. A total of 105 child-caregiver dyads
11 (95.5% of enrolled families) completed the CPASS I study protocol.
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

27 The second wave of the CPASS (CPASS II) was conducted among children with disabilities
28 aged 10-21 years and their primary caregivers between April and July in 2013 at the center.^{20, 21}
29 Research personnel invited 129 caregivers of children with disabilities to participate. A total of
30 90 caregivers (69.8%) agreed to participate in the study. Twenty children were aged 10-12 years
31 from the CPASS II. As these two studies (CPASS I and CPASS II) were conducted between
32 September 2012 and July 2013 at the same rehabilitation center in Chile, with the same staff and
33 with identical study protocols used for assessing sleep traits, we combined the results from the
34 two studies in order to have a larger sample size with increased statistical power in the present
35
36
37
38
39
40
41
42
43
44
45

46 For peer review only: <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

sample size of this pilot was determined on the basis of available resources (e.g., ActiSleep monitors) and not based on formal *a priori* sample size and statistical power determinations.

Written informed consents were obtained from primary caregivers of children with disabilities.

This study was approved by the institutional review boards of the Centro de Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human Research Administration.

Study Procedures

A psychologist administered structured questionnaires to caregivers to collect information on sociodemographic and lifestyle factors of both children and caregivers. Research staff instructed children to wear ActiSleep monitors (ActiLife, ActiGraph R&D, Florida, USA)²² on their non-dominant wrists for seven consecutive days. Although the monitors are waterproof, children were instructed to remove them from their wrists before taking showers and/or before swimming. Caregivers were also instructed to keep sleep logs of time in bed and time out of bed for their children. Electronic medical records were reviewed by a physician in order to extract children's diagnoses defined by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10).²³

Sleep Parameters

Actigraphic sleep data were collected using the ActiSleep monitors and were analyzed using the ActiLife 6 data analysis software.²² When worn during sleep episodes, the ActiSleep monitor can provide estimates of sleep onset, sleep latency, WASO, number and length of awakenings, sleep duration, and sleep efficiency. Sleep latency is the length of time taken to fall asleep, calculated as the time between “lights off” to the first period of 3 minutes of consecutive epochs scored as sleep. WASO is the number of minutes awake between sleep onset and time of final waking. Sleep efficiency is defined as the proportion of the estimated sleep periods spent asleep. Actigraphy data were collected in 1-min epochs using the zero-crossing modes, and the “Sadeh” sleep algorithm was used for children.²⁴ The majority of children (n=122, 97.6 %) had complete 7-day actigraphic sleep data; two children had 6-day actigraphic data and one child had 3-day data available for study. The averages of sleep parameters were calculated for children who had 3, 6, or 7 days of actigraphic data. There were no missing sleep log data for children included in this study. Caregivers were asked to record their children's sleep logs each morning up awakening and to make sure the sleep logs were complete. Research staff checked children's sleep logs when caregivers returned with ActiSleep monitors. Information from sleep logs were not used to substitute missing actigraphy data.

Sociodemographic Characteristics and Children's Disabilities

Interviewer-administered questionnaires were used to collect information on children's age, sex, daytime napping, medication use, caregiver-child relationship (e.g., mother), caregivers' age,

For peer employment status, and education level. Caregivers were asked to report the highest degree of

education they had completed: less than 12th grade (<high school education), high school graduate or equivalent (high school education), some college degree, or college graduate or above (>high school education). According to the ICD-10,²³ children's disabilities were grouped as: 1) mental and behavioral disorders (e.g., ADHD, autism); 2) diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); 3) diseases of the nervous system (e.g., cerebral palsy); and 4) congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

Statistical Analysis

Kolmogorov-Smirnov test was used to assess the normality of sleep parameters. Variables were described using means and standard deviations (SDs) for parametric variables and medians and interquartile ranges (IQRs) for nonparametric variables. Number of nocturnal awakenings and sleep efficiency were normally distributed, whereas sleep onset, sleep latency, WASO, awakening length, and sleep duration were not normally distributed. Student's t-test was used for age, number of awakenings, and sleep efficiency as parametric variables by child sex; Wilcoxon rank-sum test was used to test differences in nonparametric variables including sleep onset, sleep latency, WASO, awakening length, and sleep duration by child sex. Fisher's or χ^2 test was conducted to compare differences in sociodemographic factors, daytime napping, medication use, and disability groups by child sex. Analysis of variance or Kruskal-Wallis test was conducted to evaluate the differences in sleep parameters across children's disability groups and

1 A general linear model was fitted to generate least-square means and standard errors (SEs) of
2 sleep efficiency across caregivers' education levels with adjustment for children's age, sex,
3 disability, caregiver-child relationship, and caregivers' age. Univariate and multivariable linear
4 regression analyses were performed to examine the associations of caregivers' education levels
5 with sleep efficiency and the number of awakenings. Stratified analysis was conducted to
6 evaluate whether the associations between caregivers' education levels and children's sleep
7 disturbances differed according to children's disability groups. Given that we aimed to examine
8 whether children whose caregivers had lower education level were more likely to have sleep
9 disturbances (e.g., long sleep latency, long WASO) and to enhance interpretability, we created
10 categorical variables for these sleep parameters and used in logistic regression models. Odds
11 ratios (ORs) and 95% confidence intervals (CIs) were estimated using logistic regression models
12 to evaluate the associations of caregivers' educational attainment with children's long sleep
13 latency (≥ 30 vs. < 30 minutes), long WASO (≥ 90 vs. < 90 minutes), and short sleep duration (< 8
14 vs. ≥ 8 hours). These cut points were chosen based on the literature of sleep latency²⁵ and sleep
15 duration,²⁶ as well as sleep data distributions in the study (WASO median=88 minutes, sleep
16 duration median=8 hours; only 9.6% of children had sleep ≥ 9 hours). We also included a
17 variable to represent study wave (I and II) in multivariable regression models and found similar
18 results (data not shown). We conducted sensitivity analysis by including medication use and
19 daytime napping in the models and did not find that they had an impact on our results in this
20 study (data not shown). Statistical significance levels were set at $P < 0.05$ for two-sided analyses.

21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46 For peer review only. See <https://www.bmj.com/>. Statistical significance levels were set at $P < 0.05$ for two-sided analyses.

P values were not corrected for multiple testing. All tests were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

The mean age of children with disabilities was 9.2 (SD=2.2; range=6-12) years. Most caregivers were mothers (88.0%); 21.6% of caregivers reported having <high school education level (**Table 1**). There were no statistically significant differences in medication use, daytime napping, caregiver-child relationship, caregivers' age, employment status, or education level between boys and girls.

Median time for sleep onset was 22:39, sleep latency 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours (**Table 1**). The mean number of awakenings was 22.1 and sleep efficiency was 80.0%. There were no statistically significant differences in sleep parameters between boys and girls (all $P > 0.05$). Overall, 43.2% of children had sleep latency ≥ 30 minutes, 51.2% had short sleep <8 hours, and 77.6% had low sleep efficiency <85%.

There were no significant differences in sleep parameters across disability groups (**Supplementary Figure 1**), except for the number of nocturnal awakenings (**Supplementary Table 1**). Children with diseases of musculoskeletal system and connective tissue, skin and subcutaneous tissue appeared to have more awakenings, reflecting more fragmented sleep, than

1 Children whose caregivers had <high school had longer sleep latency, longer WASO, longer
2 awakening length, and lower sleep efficiency compared to children whose caregivers had >high
3 school (**Figure 1, Table 2**). Although children of caregivers with <high school tended to have
4 later sleep onset, higher number of awakenings, and shorter sleep duration when compared to
5 children of caregivers with higher education, these differences did not reach statistical
6 significance.
7

8 Our general linear model with adjustment for child age, sex, disability group, caregiver-child
9 relationship, and caregiver age showed that the mean sleep efficiency was the lowest among
10 children of caregivers with <high school (75.7% [SE=1.4]), followed by children of caregivers
11 with high school (80.4% [SE=1.0]) and >high school (81.9% [SE=1.0]). Univariate and
12 multivariable linear regression analyses showed no significant associations between caregivers'
13 education levels and children's awakening number. However, compared to children whose
14 caregivers had >high school, children of caregivers with <high school had significantly lower
15 sleep efficiency (adjusted beta=-6.3, SE=1.7; P=0.001) (**Table 3**). Caregivers' educational
16 attainment was positively and significantly associated with children's sleep efficiency in the
17 univariate model ($P_{trend}=0.001$) and the multivariable model ($P_{trend}<0.001$).
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

43 As shown in **Table 4** based on logistic regression models, compared to children whose
44 caregivers had >high school, children of caregivers with <high school had higher odds of longer

45 For peer review only
46
47
48
49

sleep latency ≥ 30 minutes (adjusted OR=3.27; 95% CI=1.12-9.61) and longer WASO ≥ 90 minutes (OR=5.95; 95% CI=1.91-18.53). Caregivers' education levels were inversely and significantly associated with children's sleep latency and WASO (both $P_{trend} < 0.05$). Children's short sleep duration (< 8 hours) was not associated with caregivers' low educational level (OR=0.78; 95% CI=0.28-2.18).

The associations between caregivers' education and children's sleep efficiency varied little according to disability groups (data not shown in tables). For example, among children with mental and behavioral disorders, children of caregivers with $<$ high school had lower sleep efficiency (beta=-6.2, SE=2.2; $P=0.006$), after adjustment for children's age, sex, caregiver-child relationship, and caregivers' age. Similar results were found for children with other disabilities.

DISCUSSION

In this cross-sectional pilot study, we assessed sleep patterns using wrist actigraphy over seven consecutive days among Chilean children with disabilities. We found that actigraphy-measured sleep disturbances including long sleep latency (median=27 minutes), long WASO (median=88 minutes), short sleep duration (median=8 hours), high number of nocturnal awakenings (mean=22), and low sleep efficiency (mean=80%) were common among children. These findings indicate that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency), and have

increased sleep fragmentation (increased nocturnal awakenings). These indices are common in

1 insomnia, which may occur secondary to chronic health conditions, and for many conditions, is
2 associated with poor quality of life and increased disease-specific health burden including
3 behavioral and cognitive problems.^{27,28} We also found strong associations between caregivers'
4 low educational attainment and children's sleep disturbances (e.g., low sleep efficiency)
5 independent of children's disability type and other covariates from both children and caregivers.
6
7 To our knowledge, this is the first study to specifically quantify actigraphy-measured sleep
8 patterns among children with disabilities in relation to caregivers' education levels. Furthermore,
9 we address these questions among Patagonian Chilean children with disabilities, an understudied
10 population in South America.
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45

46 Children with a wide range of disabilities have been reported to have sleep disturbances,
47 including prolonged sleep latency, increased WASO, short sleep duration, and decreased sleep
48 efficiency in Europe and other developed countries including Canada and New Zealand.^{4-6, 29, 30}
49 For example, in a small study of 8 UK children with mucopolysaccharidosis aged 2-15 years,
50 median actigraphy-measured sleep latency was 35.4 minutes, WASO 83.4 minutes, and sleep
51 efficiency was 75.6%.³⁰ Allik et al reported that children aged 8-12 years with Asperger
52 syndrome and high-functioning autism in Sweden had actigraphy-measured longer sleep latency
53 (mean=32 minutes) and lower sleep efficiency (mean=87%) than controls.⁶ In a study of children
54 aged 5-11 years with ADHD in Denmark, average sleep latency was 26 minutes and 31% of
55 children had sleep latency >30 minutes.⁵ A case-control study using 5 nights of actigraphy for 15
56 school-aged children with traumatic brain injury and 15 school-aged siblings in the UK reported

57 For personal use only: all rights reserved. Downloaded from <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

1 that brain injury was significantly associated with children's longer sleep latency (mean=50
2 minutes), longer WASO (mean=65 minutes), and lower sleep efficiency (mean=80%).²⁹ To our
3 knowledge, no research has been conducted on objectively measured sleep parameters in South
4 America (e.g., Chile) among children with disabilities, an understudied sample. In our study of
5 Chilean children with autism and other disabilities, the median of actigraphy-measured sleep
6 latency was 27 minutes, WASO was 88 minutes, and the mean of sleep efficiency was 80%,
7 which were similar to previous research findings.^{5, 29, 30} We also found that a high proportion of
8 Chilean children with disabilities experienced actigraphy-measured sleep disturbances: 43% of
9 children had sleep latency ≥ 30 minutes, 51% had short sleep < 8 hours (90% of children had
10 sleep duration < 9 hours), and 78% had sleep efficiency $< 85\%$. Although school-aged children
11 are recommended to have at least 9 hours of sleep,^{26, 31} in our study, only 10% of Chilean
12 children with disabilities had sleep duration ≥ 9 hours. Gibbs et al reported that among 8 children
13 aged 4-15 years with Prader-Willi syndrome in New Zealand, median 7-night actigraphy-
14 measured WASO was 95 minutes.³² Corkum et al reported the average of awakenings was 15
15 among Canadian children with ADHD (aged 7-11 years).⁴ In our current study, the average
16 number of nocturnal awakenings was 22 among Chilean children with ADHD and other
17 disabilities. Our study along with previous research suggests that children with disabilities have
18 difficulties initiating and maintaining good sleep.

19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44 Several researchers have reported that children with disabilities have late sleep onset.^{33, 34} A

45
46 For peer review only: <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

1 that the mean of 7-day actigraphy-measured sleep onset time was 21:32.³³ In this study, we
2 found that median sleep onset time was 22:39 among Chilean children with autism and other
3 disabilities. Unique climate (e.g., late sunset) and lifestyle characteristics (e.g., late mealtime) in
4 the Patagonia region may have partly contributed to children's late sleep onset time.^{13,18} Our
5 findings of late sleep onset are generally consistent with literature for children in this age range.
6
7 For example, a cross-sectional study of 96 healthy Chilean children aged 10 years found that the
8 mean of overnight polysomnography-measured sleep onset time was 23:10 for children with
9 normal weight and 23:20 for children with overweight and obesity.³⁵ Another study of 58 healthy
10 children aged 11-13 years in the US showed that the mean of 4-day actigraphy-measured sleep
11 onset time was 23:27.³⁶ In the Cleveland Children's Sleep and Health Study, 14.8% of US
12 children aged 8-11 years had bedtime 23:00 or later.¹⁴ Future research is warranted to examine
13 potential risk factors of late bedtime such as daytime napping and how to improve sleep onset
14 time among children with disabilities.
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

32 It has been reported that children whose caregivers have low education levels are more likely to
33 have adverse health outcomes, such as great body weight¹⁶ and poor quality of life.¹⁷ McDonald
34 et al found that lower maternal education was independently associated with parent-reported
35 shorter sleep (<11 hours/night) among young children.¹² Although several studies have reported
36 that parental education is associated with child health,^{12,15} we are unaware of published reports
37 that have investigated whether and how caregivers' education levels are related to objectively
38 measured sleep problems among children with disabilities. In our study, caregivers' education

39
40
41
42
43
44
45
46 For peer review only: <https://www.bmj.com/> | <https://open.bmj.com/> | <https://www.bmj.com/>

level in relation to children's sleep disturbances was substantiated through statistically significant association as shown in univariate and multivariable linear and logistic regression models. Our study suggests the importance of tailoring sleep education for caregivers with lower educational attainment to improve children's sleep health. We considered low educational attainment a proxy for low socioeconomic status (SES). It has been reported that educational levels and SES are highly correlated.³⁷ Low SES, as well as low education, has been related to high risk for cardiovascular disease, cancer, and mortality.³⁸ Parental SES has been inversely associated with negative child health outcomes including cardiovascular disease and mortality.³⁹⁴⁰ Some of the burden from low parental education level may be attributable to relatively lower health literacy, particularly sleep health literacy, which is pertinent to our pilot observations in the focus group study¹³ and also in this pilot epidemiologic study.

Parents with low education levels may lack knowledge and resources about children's sleep practices and disabilities, resulting in adverse parenting practices known to affect sleep hygiene such as less limit setting, more variability in routines important to establish regular sleep patterns, suboptimal configuration of bedrooms to optimize sleep, inappropriate use of electronic devices, and meal timing in relationship to sleep. Better-educated parents may have more access to information about sleep and disabilities possibly through the internet or group membership with other parents of children diagnosed with disabilities. Future research should consider the impact of providing education and support such as sleep hygiene education, as well as initiatives

to provide social support for parents and families of children with disabilities. Although our data

education among targeted caregivers.¹³ Pediatricians and family physicians can be trained to provide adequate advice and educational messages (e.g., sleep health) to pediatric patients and their families.⁴⁴

Our study has several limitations. First, as this was a cross-sectional pilot study that aimed to examine the feasibility of conducting future research with a larger sample size in this underserved population, we did not have a control group of children without disabilities. Second, this study was limited by its modest sample size and the heterogeneity of disabilities represented among children studied. As such, the confidence intervals were wider for some groups (e.g., the less than high school education group) and we were not able to report associations specific to any single disability category (e.g., autism). Third, we did not collect information pertaining to some aspects of sleep which may be associated with low education levels such as caregivers' shift work, sleep hygiene, and other factors such as co-sleeping, lack of knowledge about sleep health, or inability to obtain medications to treat sleep or conditions in this study. Hence we were not able to quantify the influence of these factors on children's sleep patterns. Our findings also focused on caregivers (majority were mothers) of children with disabilities in Chile, and may not be generalizable to other populations/groups. Although accepted to provide an objective measure of sleep-wake cycle, actigraphy has its limitations. For example, periods of quiet wakefulness may be interpreted by the device as sleep, and periods of restless sleep may be interpreted by the device as wakefulness.^{8, 45} Recent literature has indicated limitations of actigraphy for accurately

capturing children's awakenings.⁴⁶ Our study has indicated that children with diseases of the

musculoskeletal system and connective, skin, and subcutaneous tissue have more awakenings

because their restless sleep may be represented by actigraphy as awakenings, and/or due to medication use or body pain. Despite this, actigraphy has been well validated for objective estimation of nocturnal sleep parameters across age groups in the natural sleep environment.⁹ As this was an exploratory study that aimed to examine whether parental education was associated with children's sleep disturbances, we did not adjust for multiple comparisons in this study. In addition, the simple adjustments for multiple comparisons might be overly conservative because many sleep problems (e.g., long WASO, low sleep efficiency) were correlated.

CONCLUSIONS

This cross-sectional pilot study suggests the feasibility of using wrist-actigraphy as a means of collecting objective measures of sleep patterns among Chilean Patagonian children with disabilities. Using collected data, we noted that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep fragmentation (increased nocturnal awakenings). Among children with disabilities, lower levels of caregivers' educational attainment are strongly associated with children's sleep disturbances and these associations appear to be independent of children's age, sex, disability group, caregiver-child relationship, and caregiver age. Parental support and education programs directed to families with low education levels may be of particular importance for sleep behavior intervention among children with disabilities. Larger studies,

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

using wrist-actigraphy methods to objectively measure sleep in this relatively understudied

population, are warranted to confirm our findings. Future research is also needed regarding the effects of sleep education intervention as well as social support to low educational families of children with disabilities on sleep health, with taking into account of different cultural backgrounds.

Contributors' Statement

All of the authors have agreed to the content of this manuscript. XC conceptualized and designed the study, supervised data collection, carried the initial analyses, and drafted the initial manuscript. JCV and CB carried out the field survey, supervised data collection, and critically reviewed and revised the manuscript. MP carried out the field survey, coordinated data collection at the study site, and reviewed the manuscript. BG helped develop the study protocol, and critically reviewed and revised the manuscript. SR critically reviewed and revised the manuscript. MAW provided funding support to the study, supervised the study, conceptualized and designed the study, and critically reviewed and revised the manuscript.

Competing Interests: The authors have no competing interests to disclose. The authors alone are responsible for the content and writing of the paper.

Funding Support: This research was supported by awards from the National Institutes of Health

(National Institute on Minority Health and Health Disparities: T37-MD001449), the National Center for Research Resources (NCRR), the National Center for Advancing Translational Sciences (NCATS: 8UL1TR000170-07), and the Rose Traveling Award.

Ethics Approval: This study was approved by the institutional review boards of the Centro de Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health Office of Human Research Administration.

Data Sharing Statement: No additional data are available.

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

REFERENCES

1. World report on disability 2011. World Health Organization.
<http://www.who.int/disabilities/>. Accessed October 20, 2014
2. Churchill SS, Kieckhefer GM, Landis CA, Ward TM. Sleep measurement and monitoring in children with Down syndrome: A review of the literature, 1960-2010. *Sleep Med Rev.* 2012;16(5):477-488
3. Sung V, Hiscock H, Sciberras E, Efron D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the child and family. *Arch Pediatr Adolesc Med.* 2008;162(4):336-342
4. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep.* 2001;24(3):303-312
5. Hvolby A, Jorgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med.* 2008;162(4):323-329
6. Allik H, Larsson JO, Smedje H. Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *J Autism Dev Disord.* 2006;36(5):585-595
7. Sekine M, Chen X, Hamanishi S, Wang H, Yamagami T, Kagamimori S. The validity of sleeping hours of healthy young children as reported by their parents. *J Epidemiol.* 2002;12(3):237-242

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

8. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev.* 2002;6(2):113-124
9. Martin JL, Hakim AD. Wrist actigraphy. *Chest.* 2011;139(6):1514-1527
10. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcantara C, et al. Racial/Ethnic differences in sleep disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA). *Sleep.* 2015;38(6):877-888
11. Mezick EJ, Matthews KA, Hall M, Strollo PJ, Jr., Buysse DJ, Kamarck TW, et al. Influence of race and socioeconomic status on sleep: Pittsburgh Sleep SCORE project. *Psychosom Med.* 2008;70(4):410-416
12. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter sleep in early childhood. *Sleep Med.* 2014;15(5):536-540
13. Chen X, Gelaye B, Velez JC, Pepper M, Gorman S, Barbosa C, et al. Attitudes, beliefs, and perceptions of caregivers and rehabilitation providers about disabled children's sleep health: a qualitative study. *BMC Pediatr.* 2014;14:245
14. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner HL, Redline S. Effects of the home environment on school-aged children's sleep. *Sleep.* 2005;28(11):1419-1427
15. Magana S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services among latino children with autism spectrum disorders. *Intellec Dev Disabil.* 2013;51(3):141-153

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
16. Cameron AJ, van Stralen MM, Brug J, Salmon J, Bere E, Chinapaw MJ, et al. Television in the bedroom and increased body weight: potential explanations for their relationship among European schoolchildren. *Pediatr Obes*. 2013;8(2):130-141
 17. Kumar S, Kroon J, Laloo R. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Health Qual Life Outcomes*. 2014;12:41
 18. Velez JC, Fitzpatrick AL, Barbosa CI, Diaz M, Urzua M, Andrade AH. Nutritional status and obesity in children and young adults with disabilities in Punta Arenas, Patagonia, Chile. *Int J Rehabil Res*. 2008;31(4):305-313
 19. International Classification of Functioning, Disability and Health (ICF). <http://www.who.int/classifications/icf/en/>. Accessed July 16, 2015
 20. Chen X, Gelaye B, Velez JC, Barbosa C, Pepper M, Andrade A, et al. Caregivers' hair cortisol: A possible biomarker of chronic stress is associated with obesity measures among children with disabilities. *BMC Pediatr*. 2015;15:9
 21. Chen X, Velez JC, Barbosa C, Pepper M, Andrade A, Stoner L, et al. Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress*. 2015;18(1):20-28
 22. ActiLife 6. ActiLife, ActiGraph R&D. <http://www.theactigraph.com/products/actisleep/>. Accessed November 12, 2014

23. International Classification of Diseases (ICD-10). ICD-10 International Statistical Classification of Diseases and Related Health Problems. 10th Revision. Volume 2. Instruction manual Published 2010
24. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, et al. Estimating sleep patterns with activity monitoring in children and adolescents: how many nights are necessary for reliable measures? *Sleep*. 1999;22(1):95-103
25. Adkins KW, Molloy C, Weiss SK, Reynolds A, Goldman SE, Burnette C, et al. Effects of a standardized pamphlet on insomnia in children with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S139-144
26. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity (Silver Spring)*. 2008;16(2):265-274
27. Lipton J, Becker RE, Kothare SV. Insomnia of childhood. *Curr Opin Pediatr*. 2008;20(6):641-649
28. Malow BA, Byars K, Johnson K, Weiss S, Bernal P, Goldman SE, et al. A practice pathway for the identification, evaluation, and management of insomnia in children and adolescents with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S106-124
29. Sumpter RE, Dorris L, Kelly T, McMillan TM. Pediatric sleep difficulties after moderate-severe traumatic brain injury. *J Int Neuropsychol Soc*. 2013;19(7):829-834
30. Mahon LV, Lomax M, Grant S, Cross E, Hare DJ, Wraith JE, et al. Assessment of sleep in children with mucopolysaccharidosis type III. *PloS One*. 2014;9(2):e84128

31. For peer review only. The National Sleep Foundation. <http://sleepfoundation.org/>. Accessed October 12, 2014

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
32. Gibbs S, Wiltshire E, Elder D. Nocturnal sleep measured by actigraphy in children with Prader-Willi syndrome. *J Pediatr*. 2013;162(4):765-769
33. Goodlin-Jones BL, Tang K, Liu J, Anders TF. Sleep patterns in preschool-age children with autism, developmental delay, and typical development. *J Am Acad Child Adolesc Psychiatry*. 2008;47(8):930-938
34. Malow BA, Adkins KW, Reynolds A, Weiss SK, Loh A, Fawkes D, et al. Parent-based sleep education for children with autism spectrum disorders. *J Autism Dev Disord*. 2014;44(1):216-228
35. Chamorro R, Algarin C, Garrido M, Causa L, Held C, Lozoff B, et al. Night time sleep macrostructure is altered in otherwise healthy 10-year-old overweight children. *Int J Obes (Lond)*. 2014;38(8):1120-1125
36. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc Health*. 2009;45(4):326-334
37. Cassidy A, Drotar D, Ittenbach R, Hottinger S, Wray J, Wernovsky G, Newburger JW, Mahony L, Mussatto K, Cohen MI, Marino BS. The impact of socioeconomic status on health related quality of life for children and adolescents with heart disease. *Health Qual Life Outcomes*. 2013;11:99
38. Vathesatogkit P, Batty GD, Woodward M. Socioeconomic disadvantage and disease-specific mortality in Asia: systematic review with meta-analysis of population-based

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
39. Ebrahim S, Montaner D, Lawlor DA. Clustering of risk factors and social class in childhood and adulthood in British women's heart and health study: cross sectional analysis. *BMJ*. 2004; 328(7444):861
40. Kim J, Son M. The extent and distribution of inequalities in childhood mortality by cause of death according to parental socioeconomic positions: a birth cohort study in South Korea. *Soc Sci Med*. 2009;69(7):1116-1126
41. Owens JA, Jones C, Nash R. Caregivers' knowledge, behavior, and attitudes regarding healthy sleep in young children. *J Clin Sleep Med*. 2011;7(4):345-350
42. Galland BC, Elder DE, Taylor BJ. Interventions with a sleep outcome for children with cerebral palsy or a post-traumatic brain injury: a systematic review. *Sleep Med Rev*. 2012;16(6):561-573
43. Reed HE, McGrew SG, Artibee K, Surdkya K, Goldman SE, Frank K, et al. Parent-based sleep education workshops in autism. *J Child Neurol*. 2009;24(8):936-945
44. Halal CS, Nunes ML. Education in children's sleep hygiene: which approaches are effective? A systematic review. *J Pediatr*. 2014;90(5):449-456
45. Johnson KP, Giannotti F, Cortesi F. Sleep patterns in autism spectrum disorders. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):917-928
46. Meltzer LJ, Walsh CM, Traylor J, Westin AM. Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep*. 2012;35(1):159-166

Figure 1 Children’s Sleep Parameters, by Caregiver Education Levels (HS: high school)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**Table 1** Characteristics of Children with Disabilities and Their Primary Caregivers

| | Total | Boys | Girls |
|--------------------------------------|----------------------|----------------------|----------------------|
| | (n=125) | (n=69) | (n=56) |
| Child characteristics | | | |
| Age, mean (SD), years | 9.2 (2.2) | 8.8 (2.1) | 9.8 (2.3) |
| Type of disability diagnosis, % | | | |
| Mental and behavioral disorders | 48.0 | 59.4 | 33.9 |
| Diseases of musculoskeletal system | 16.8 | 10.1 | 25.0 |
| Diseases of the nervous system | 27.2 | 27.5 | 26.8 |
| Congenital/chromosomal abnormalities | 8.0 | 2.9 | 14.3 |
| Daytime napping | 16.8 | 14.5 | 19.6 |
| Medication use | 44.0 | 42.0 | 46.4 |
| Sleep parameters | | | |
| Sleep onset, median (IQR) | 22:39 (22:06, 23:08) | 22:44 (22:24, 23:08) | 22:33 (21:54, 23:09) |
| Sleep latency, median (IQR), minutes | 27.3 (15.0, 38.9) | 27.1 (14.4, 41.7) | 27.4 (15.4, 38.9) |
| WASO, median (IQR), minutes | 88.1 (65.6, 111.1) | 92.4 (64.4, 112.4) | 81.9 (66.2, 107.0) |

| | | | | |
|----|--|----------------|----------------|----------------|
| 1 | | | | |
| 2 | | | | |
| 3 | Number of awakenings, mean (SD) ^a | 22.1 (6.7) | 22.5 (6.5) | 21.6 (6.9) |
| 4 | | | | |
| 5 | Awakening length, median (IQR), minutes | 5.1 (4.2, 7.1) | 5.1 (4.2, 7.0) | 5.1 (4.2, 7.1) |
| 6 | | | | |
| 7 | Sleep duration, median (IQR), hours | 8.0 (7.5, 8.2) | 8.0 (7.3, 8.2) | 8.0 (7.5, 8.3) |
| 8 | | | | |
| 9 | Sleep efficiency, mean (SD), % ^a | 80.0 (7.2) | 79.0 (8.1) | 81.2 (5.8) |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | Caregiver characteristics | | | |
| 14 | | | | |
| 15 | Age, mean (SD), years | 38.3 (7.8) | 38.5 (7.8) | 38.0 (7.8) |
| 16 | | | | |
| 17 | Caregiver-child relationship, % | | | |
| 18 | | | | |
| 19 | Mother | 88.0 | 88.4 | 87.5 |
| 20 | | | | |
| 21 | Other | 12.0 | 11.6 | 12.5 |
| 22 | | | | |
| 23 | Employed/self-employed | 60.0 | 62.3 | 57.1 |
| 24 | | | | |
| 25 | Education level, % | | | |
| 26 | | | | |
| 27 | <High school | 21.6 | 24.6 | 17.9 |
| 28 | | | | |
| 29 | High school | 37.6 | 29.0 | 48.2 |
| 30 | | | | |
| 31 | >High school | 40.8 | 46.4 | 33.9 |
| 32 | | | | |
| 33 | | | | |
| 34 | | | | |
| 35 | | | | |

36 Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Of these sleep parameters, only number of awakenings and sleep efficiency were normally distributed (Kolmogorov-
4
5 Smirnov test: $P > 0.05$). While Student's t-test was used for number of awakenings and sleep efficiency, Wilcoxon rank-
6
7 sum test was used for the other sleep parameters.
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3 **Table 2** Children's Sleep Parameters, By Caregivers' Education Levels
4

| 5 | 6 Sleep parameters | 7 <High school | 8 High school | 9 >High school |
|----|---|-------------------------|-------------------------|-------------------------|
| 10 | | 11 (n=27) | 12 (n=47) | 13 (n=51) |
| 14 | 15 Sleep onset, median (IQR) | 16 23:05 (22:17, 23:23) | 17 22:31 (21:55, 23:04) | 18 22:39 (22:24, 23:02) |
| 19 | 20 Sleep latency, median (IQR), minutes | 21 35.6 (17.3, 53.7) | 22 27.1 (17.4, 38.4) | 23 23.6 (11.1, 35.9) |
| 24 | 25 WASO, median (IQR), minutes | 26 99.1 (88.1, 121.0) | 27 77.1 (63.4, 103.4) | 28 77.0 (57.6, 106.0) |
| 29 | 30 Number of awakenings, mean (SD) ^a | 31 23.1 (5.7) | 32 21.2 (6.3) | 33 22.4 (7.5) |
| 34 | 35 Awakening length, median (IQR), minutes | 36 6.9 (5.0, 9.5) | 37 5.2 (4.2, 7.2) | 38 4.7 (3.9, 5.7) |
| 39 | 40 Sleep duration, median (IQR), hours | 41 7.9 (7.3, 8.4) | 42 8.0 (7.6, 8.2) | 43 8.0 (7.4, 8.2) |
| 44 | 45 Sleep efficiency, mean (SD), % ^a | 46 75.9 (7.0) | 47 80.5 (7.3) | 48 81.8 (6.5) |

49 Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

50 Sleep efficiency and number of awakenings were normally distributed in this study.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**Table 3** Linear Regression Models for Associations between Caregiver Education and Child Sleep Parameters

| | Number of awakenings | | Sleep efficiency (%) | |
|---|----------------------|--------------|----------------------|------------------|
| | Beta (SE) | P value | Beta (SE) | P value |
| Univariate model | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -1.2 (1.3) | 0.384 | -1.3 (1.4) | 0.357 |
| <High school | 0.7 (1.6) | 0.662 | -5.9 (1.7) | <0.001 |
| <i>P value for trend test</i> | | <i>0.838</i> | | <i>0.001</i> |
| Multivariable model^a | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -0.6 (1.4) | 0.674 | -1.6 (1.4) | 0.269 |
| <High school | 1.9 (1.7) | 0.245 | -6.3 (1.7) | 0.001 |
| <i>P value for trend test</i> | | <i>0.364</i> | | <i><0.001</i> |

Abbreviation: SE, standard error.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

Table 4 Logistic Regression Models for Associations between Caregiver Education and Child Sleep Disturbances

| | Sleep latency ≥ 30 | | WASO ≥ 90 | | Sleep duration |
|--|-------------------------|---------|--------------------|---------|------------------|
| | vs. <30 minutes | | vs. <90 minutes | | vs. <8 |
| | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) |
| Univariate model | | | | | |
| Caregiver education (ref: >high school) | | | | | |
| High school | 0.95 (0.42, 2.17) | 0.911 | 1.36 (0.61, 3.04) | 0.449 | 0.72 (0.33, 1.6) |
| <High school | 3.37 (1.26, 8.98) | 0.015 | 4.43 (1.58, 12.38) | 0.005 | 0.89 (0.35, 2.2) |
| <i>P value for trend test</i> | | 0.029 | | 0.006 | |
| Multivariable model | | | | | |
| Caregiver education (ref: >high school) ^a | | | | | |
| High school | 1.02 (0.42, 2.45) | 0.966 | 1.38 (0.58, 3.30) | 0.468 | 0.70 (0.30, 1.6) |
| <High school | 3.27 (1.12, 9.61) | 0.031 | 5.95 (1.91, 18.53) | 0.002 | 0.78 (0.28, 2.1) |
| <i>P value for trend test</i> | | 0.056 | | 0.004 | |

Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; WASO, wake after sleep onset.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

Figure 1 Children's Sleep Parameters, by Caregiver Education Levels (HS: high school)

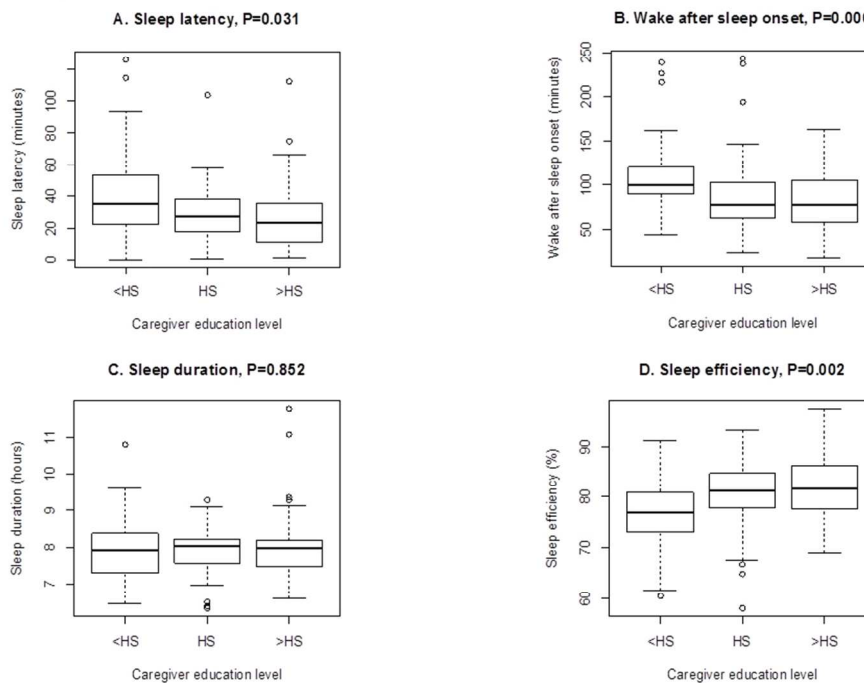


Figure in TIFF format
254x190mm (96 x 96 DPI)

View only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Supplementary Table 1 Children's Sleep Parameters, By Types of Disability Diagnoses

| Sleep parameters | Diagnosis I (n=60) | Diagnosis II (n=21) | Diagnosis III (n=34) | Diagnosis IV (n=10) | P value |
|--|-----------------------|------------------------|-------------------------|------------------------|------------|
| Sleep onset, median (IQR) | 22:35 (22:04, 23:03) | 23:05 (22:25, 23:22) | 22:37 (22:19, 23:05) | 22:35 (21:45, 23:03) | 0.187 |
| Sleep latency, median (IQR), minutes | 24.1 (14.7, 40.1) | 28.1 (22.1, 43.0) | 28.8 (14.1, 38.4) | 30.5 (9.1, 39.4) | 0.804 |
| WASO, median (IQR), minutes | 78.4 (63.5, 104.9) | 103.3 (75.0, 123.7) | 89.1 (61.7, 100.0) | 94.0 (69.9, 117.9) | 0.252 |
| Number of awakenings, mean (SD) ^a | 22.4 (6.6) | 25.1 (5.1) | 19.3 (6.5) | 23.6 (7.6) | 0.011 |
| Sleep duration, median (IQR), hours | 8.0 (7.7, 8.3) | 7.6 (7.0, 8.0) | 8.0 (7.4, 8.3) | 8 (7.1, 8.5) | 0.138 |
| Sleep efficiency, mean (SD), % ^a | 81.2 (6.5) | 78.2 (6.2) | 79.5 (8.6) | 78.3 (8.2) | 0.309 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

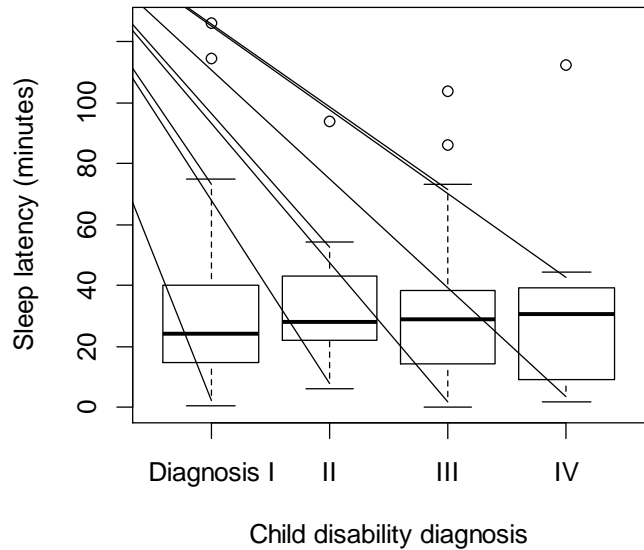
Only sleep efficiency (%) and number of awakenings were normally distributed (Kolmogorov-Smirnov test: $p > 0.05$).

^aAnalysis of variance was used for sleep efficiency and number of awakenings (normally distributed), while Kruskal-Wallis test was used for other sleep parameters.

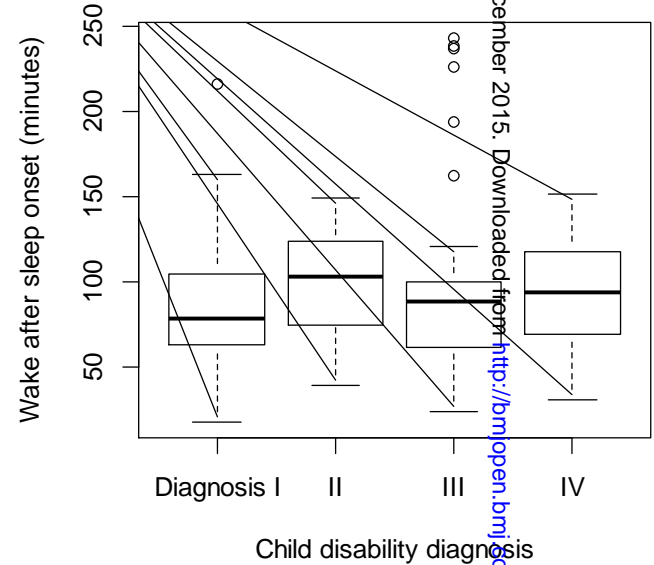
Diagnosis I: mental and behavioral disorders (e.g., autism, ADHD, mental retardation); Diagnosis II: disease of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); Diagnosis III: diseases of the nervous system (e.g., cerebral palsy); Diagnosis IV: congenital malformations, deformations and chromosomal abnormalities (e.g. Down syndrome).

Supplementary Figure 1 Children's Sleep Parameters, by Disability Diagnoses

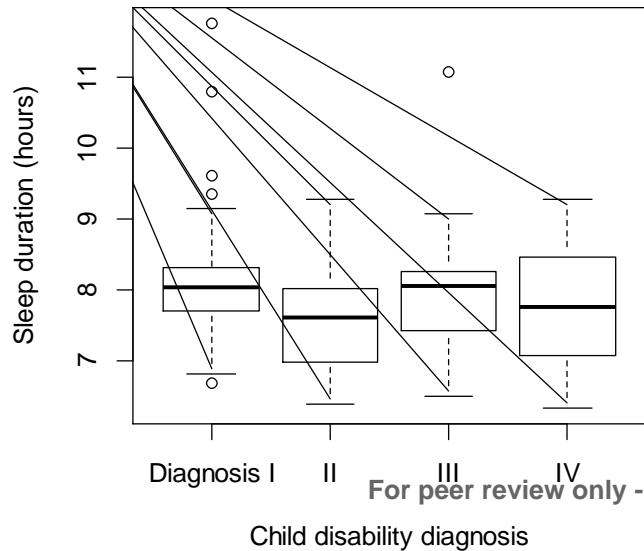
A. Sleep latency, P=0.804



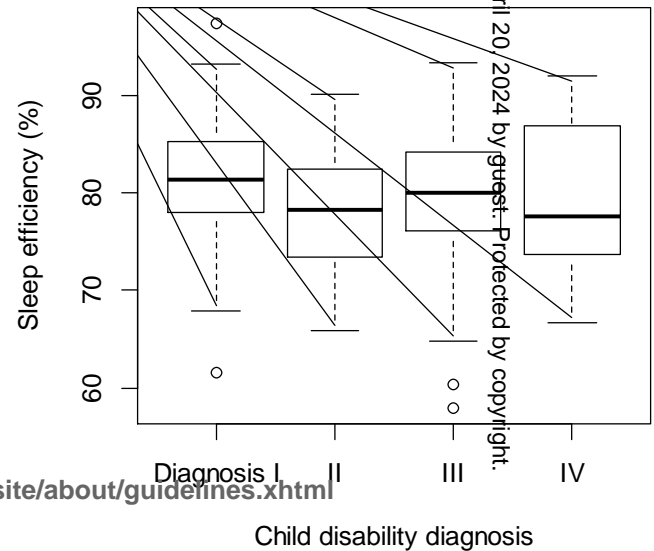
B. Wake after sleep onset, P=0.252



C. Sleep duration, P=0.138



D. Sleep efficiency, P=0.309



0-0855 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> by guest. Protected by copyright. April 20, 2024

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|------------------------------|---------|---|
| Title and abstract | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including hypotheses |
| Methods | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (a) <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement). |
| Bias | 9 | |
| Study size | 10 | This is a cross-sectional, pilot study. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions |
| Results | | |
| Participants | 13 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| Descriptive data | 14 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| Outcome data | 15 | <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

Discussion

| | | |
|------------------|----|--|
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

Other information

| | | |
|---------|----|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study. |
|---------|----|---|

For peer review only

BMJ Open

Evaluation of Actigraphy-Measured Sleep Patterns among Children with Disabilities and Associations with Caregivers' Educational Attainment: Results from a Cross-Sectional Study

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2015-008589.R4 |
| Article Type: | Research |
| Date Submitted by the Author: | 16-Oct-2015 |
| Complete List of Authors: | Chen, Xiaoli; Harvard T.H. Chan School of Public Health, Department of Epidemiology Velez, Juan Carlos; Centro de Rehabilitación Club de Leones Cruz del Sur, Barbosa, Clarita; Centro de Rehabilitación Club de Leones Cruz del Sur, Pepper, Micah; Centro de Rehabilitación Club de Leones Cruz del Sur, Gelaye, Bizu; Harvard T.H. Chan School of Public Health, Department of Epidemiology Redline, Susan; Brigham and Women's Hospital, Division of Sleep and Circadian Disorders; Harvard Medical School, Department of Medicine Williams, Michelle; Harvard T.H. Chan School of Public Health, Department of Epidemiology |
| Primary Subject Heading: | Paediatrics |
| Secondary Subject Heading: | Public health, Epidemiology |
| Keywords: | SLEEP MEDICINE, Community child health < PAEDIATRICS, PUBLIC HEALTH, EPIDEMIOLOGY |
| | |

SCHOLARONE™
Manuscripts

BMJ Open
Evaluation of Actigraphy-Measured Sleep Patterns among Children with Disabilities and Associations with Caregivers' Educational Attainment: Results from a Cross-Sectional Study

Xiaoli Chen, MD, MPH, PhD*¹, Juan Carlos Velez, MD², Clarita Barbosa, MD², Micah Pepper, MPH², Bizu Gelaye, MPH, PhD¹, Susan Redline, MD, MPH^{1,3,4}, Michelle A. Williams, ScD¹

¹Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA 02115, USA

²Centro de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile

³Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston MA 02115

⁴Department of Medicine, Harvard Medical School, Boston, MA 02115, USA

***Address correspondence to:** Xiaoli Chen, MD, MPH, PhD, Department of Epidemiology, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, Phone: 617-432-0067, xchen@hsph.harvard.edu

SHORT TITLE: Sleep patterns among children with disabilities

Abstract: 286 words

Text: 4,368 words

Tables: 4; Figures: 1

Supplementary table: 1

Supplementary figure: 1

KEY WORDS

Child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

ABBREVIATIONS

ADHD: attention-deficit/hyperactivity disorder

ASD: autism spectrum disorder

CI: confidence interval

CPASS: Chile Pediatric and Adult Sleep and Stress Study

ICD: International Classification of Diseases

For peer review only
 ICF-CY: International Classification of Functioning, Disability and Health for Children and Youth

IQR: interquartile range
OR: odds ratio
SD: standard deviation
SE: standard error
WASO: wake after sleep onset

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

Abstract

Objectives: To use wrist-actigraphy to collect objective measures of sleep and to characterize actigraphy-measured sleep patterns among children with disabilities. We also assessed the extent to which, if at all, caregivers' education is associated with children's sleep disturbances.

Design: Cross-sectional study.

Setting: A rehabilitation center in the Patagonia region, Chile.

Methods: This study was conducted among 125 children aged 6-12 years with disabilities (boys: 55.2%) and their primary caregivers in Chile. Children wore ActiSleep monitors for seven days. A general linear model was fitted to generate least-square means and standard errors (SEs) of sleep efficiency (proportion of the sleep period spent asleep) across caregivers' education levels adjusting for children's age, sex, disability type, caregiver-child relationship, and caregivers' age. Multivariable logistic regression analyses were conducted to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of longer sleep latency (≥ 30 minutes) and longer wake after sleep onset (WASO) (≥ 90 minutes) (a measure of sleep fragmentation) in relation to caregivers' educational attainment.

Results: Median sleep latency was 27.3 minutes, WASO 88.1 minutes, and sleep duration 8.0 hours. Mean sleep efficiency was 80.0%. Caregivers' education was positively and significantly associated with children's sleep efficiency ($P_{trend} < 0.001$). Adjusted mean sleep efficiency was 75.7% (SE=1.4) among children of caregivers <high school education, and 81.9% (SE=1.0) among children of caregivers >high school education. Compared to children whose caregivers

had >high school, children of caregivers with <high school had higher odds of longer sleep

latency (OR=3.27; 95% CI=1.12-9.61) and longer WASO (OR=5.95; 95% CI=1.91-18.53).

Associations were consistent across disability types.

Conclusions: Children with disabilities experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency). Among children with disabilities, lower level of caregivers' education is associated with more sleep disturbances.

KEY WORDS: child, disability, caregiver, education, sleep parameter, actigraphy, sleep duration, sleep efficiency, sleep latency, wake after sleep onset

Strengths and limitations of this study

- This cross-sectional study is strengthened by its use of wrist-actigraphy which has been well validated for objective estimation of nighttime sleep parameters in the natural sleep environment.
- Our study was unique in being the first study to examine the associations between caregivers' education and actigraphy-measured sleep among children with disabilities.
- Its strength also lies in the statistical analysis that was performed using univariate and multivariable linear and logistic regression models.
- This is a cross-sectional study with a small sample size and high heterogeneity of disabilities included.

INTRODUCTION

1 Approximately 150 million children live with disabilities worldwide.¹ Sleep disturbances,
2 particularly difficulty initiating and maintaining sleep, are commonly reported among children
3 with a wide range of disabilities including Down syndrome, attention-deficit/hyperactivity
4 disorder (ADHD), and autism.²⁻⁶ There are discrepancies between objective measures of sleep
5 and those reported by parents of children with disabilities.⁵ Parents may be unaware of children's
6 sleep disturbances, such as night awakenings, and tend to overestimate their children's sleep
7 duration.⁷ Inferences from prior studies are limited because investigators have relied on parental
8 report of child sleep.³ Although polysomnography is considered the gold standard for measuring
9 sleep, it is burdensome and not easily amenable for use with children who have difficulties
10 sleeping in unfamiliar surroundings. Actigraphy-based sleep offers opportunities to obtain
11 objective measures of sleep in children's typical environment. Actigraphy has been validated for
12 objective measures of sleep in clinical- and population-based studies.^{8,9}

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32 Sleep disturbances have been related to sociodemographic, environmental, and behavioral
33 factors.¹⁰⁻¹³ Children's sleep disturbances have been connected with their home environment that
34 may be influenced by caregivers' characteristics.^{13, 14} Our recent qualitative study showed that
35 while Chilean caregivers and rehabilitation providers recognized the importance of sleep health,
36 they differed in their understanding of how sleep practices influence children's sleep health.¹³

37
38
39
40
41
42
43
44 Parental ability to provide support for healthy behaviors including sleep may be influenced by

45
46 For parental education, a known factor associated with child health measures.^{12, 15-17} Magana et al

1 reported that maternal education and knowledge about autism accounted for differences in the
2 number of specialty services received by Latino children with autism spectrum disorder (ASD)
3 as compared with White children in the US.¹⁵ However, to our knowledge, little research has
4 been conducted regarding the role of caregivers' education in objectively measured sleep among
5 children with disabilities, particularly among Patagonian Chilean children, an understudied
6 population with documented high burden of obesity and related chronic disorders.¹⁸
7
8
9
10
11
12
13
14

15 This cross-sectional study was designed to use wrist-actigraphy as a means for collecting
16 objective measures of sleep patterns among children with disabilities. We also sought to
17 characterize actigraphy-measured sleep patterns and to examine whether caregivers' education
18 level is associated with sleep disturbances among children with disabilities. Specifically, we
19 sought to estimate the prevalence of actigraphy-measured sleep disturbances including long sleep
20 latency, long wake after sleep onset (WASO), short sleep duration, and poor sleep quality (low
21 sleep efficiency) among Chilean children with disabilities. Further, following up on results from
22 a previous qualitative study,¹³ we sought to determine the extent to which, if at all, caregivers'
23 low levels of educational attainment are associated with children's sleep disturbances and overall
24 poor sleep quality.
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

41 **METHODS**

42 **Participants**

43
44
45
46 For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1 The Chile Pediatric and Adult Sleep and Stress Study (CPASS) was a cross-sectional study that
2 was established in September 2012 at the Centro de Rehabilitacion Club de Leones Cruz del Sur
3 in Punta Arenas, Chile.¹³ The CPASS was designed to use wrist-actigraphy to characterize sleep
4 patterns of children with disabilities. Particular attention was paid to establishing the protocols
5 for data collection, assessing protocol adherence among children with a wide range of
6 developmental disabilities, and using collected data to preliminary assess study hypotheses.
7
8
9
10
11
12
13
14

15 The first wave of the CPASS (CPASS I) was conducted between September and December in
16 2012 among children aged 6-12 years who were receiving routine clinical care for disabilities at
17 the center and their primary caregivers. Children with disabilities in this study were those who
18 had impairments, activity limitations, and participation restrictions due to health conditions such
19 as autism, Down syndrome, and cerebral palsy, according to the World Health Organization, the
20 International Classification of Functioning, Disability and Health for Children and Youth (ICF-
21 CY).¹⁹ All children were diagnosed by a clinical care team composed of a pediatric neurologist, a
22 pediatrician with extensive experience in developmental disabilities, and a rehabilitation
23 medicine specialist using diagnostic criteria and/or standardized tests with the input of families
24 and teachers. Primary caregivers were parents, grandparents, relatives, or other adults and were
25 principally responsible for children's well-being and did not have developmental or intellectual
26 disabilities. Research staff talked with caregivers to determine if they could complete the
27 interviewer-administered questionnaire survey. In addition, a physician helped confirm that
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45

46 For peer review only - not certified by peer review. For peer review only - not certified by peer review. Of 153 children whose families were
47
48
49

1 contacted via telephone by research staff, 110 adult caregivers (71.9%) consented to participate
2
3 in this study. A total of 110 children and caregivers (one caregiver per child) were recruited in
4
5 the CPASS I. Five children were excluded from this study due to fewer than 3 days of actigraphy
6
7 data: four children removed monitors after day one or day two of the study; one child lost the
8
9 monitor on day two. These children had no sleep log data. A total of 105 child-caregiver dyads
10
11 (95.5% of enrolled families) completed the CPASS I study protocol.
12
13
14

15 The second wave of the CPASS (CPASS II) was conducted among children with disabilities
16
17 aged 10-21 years and their primary caregivers between April and July in 2013 at the center.^{20, 21}
18
19 Research personnel invited 129 caregivers of children with disabilities to participate. A total of
20
21 90 caregivers (69.8%) agreed to participate in the study. Twenty children were aged 10-12 years
22
23 from the CPASS II. As these two studies (CPASS I and CPASS II) were conducted between
24
25 September 2012 and July 2013 at the same rehabilitation center in Chile, with the same staff and
26
27 with identical study protocols used for assessing sleep traits, we combined the results from the
28
29 two studies in order to have a larger sample size with increased statistical power in the present
30
31 analysis. In total, 125 children aged 6-12 years were included in the current study. The final
32
33 sample size of this study was determined on the basis of available resources (e.g., ActiSleep
34
35 monitors) and not based on formal *a priori* sample size and statistical power determinations.
36
37
38
39
40
41
42
43

44 Written informed consents were obtained from primary caregivers of children with disabilities.
45

46 For peer review only: This study was approved by the institutional review boards of the Centro de Rehabilitacion Club
47

Research Administration.

Study Procedures

A psychologist administered structured questionnaires to caregivers to collect information on sociodemographic and lifestyle factors of both children and caregivers. Research staff instructed children to wear ActiSleep monitors (ActiLife, ActiGraph R&D, Florida, USA)²² on their non-dominant wrists for seven consecutive days. Although the monitors are waterproof, children were instructed to remove them from their wrists before taking showers and/or before swimming. Caregivers were also instructed to keep sleep logs of time in bed and time out of bed for their children. Electronic medical records were reviewed by a physician in order to extract children's diagnoses defined by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10).²³

Sleep Parameters

Actigraphic sleep data were collected using the ActiSleep monitors and were analyzed using the ActiLife 6 data analysis software.²² When worn during sleep episodes, the ActiSleep monitor can provide estimates of sleep onset, sleep latency, WASO, number and length of awakenings, sleep duration, and sleep efficiency. Sleep latency is the length of time taken to fall asleep, calculated as the time between "lights off" to the first period of 3 minutes of consecutive epochs

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

scored as sleep. WASO is the number of minutes awake between sleep onset and time of final

waking. Sleep efficiency is defined as the proportion of the estimated sleep periods spent asleep. Actigraphy data were collected in 1-min epochs using the zero-crossing modes, and the “Sadeh” sleep algorithm was used for children.²⁴ The majority of children (n=122, 97.6 %) had complete 7-day actigraphic sleep data; two children had 6-day actigraphic data and one child had 3-day data available for study. The averages of sleep parameters were calculated for children who had 3, 6, or 7 days of actigraphic data. There were no missing sleep log data for children included in this study. Caregivers were asked to record their children's sleep logs each morning up awakening and to make sure the sleep logs were complete. Research staff checked children's sleep logs when caregivers returned with ActiSleep monitors. Information from sleep logs were not used to substitute missing actigraphy data.

Sociodemographic Characteristics and Children's Disabilities

Interviewer-administered questionnaires were used to collect information on children's age, sex, daytime napping, medication use, caregiver-child relationship (e.g., mother), caregivers' age, employment status, and education level. Caregivers were asked to report the highest degree of education they had completed: less than 12th grade (<high school education), high school graduate or equivalent (high school education), some college degree, or college graduate or above (>high school education). According to the ICD-10,²³ children's disabilities were grouped as: 1) mental and behavioral disorders (e.g., ADHD, autism); 2) diseases of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); 3) diseases of the

nervous system (e.g., cerebral palsy); and 4) congenital malformations, deformations and chromosomal abnormalities (e.g., Down syndrome).

Statistical Analysis

Kolmogorov-Smirnov test was used to assess the normality of sleep parameters. Variables were described using means and standard deviations (SDs) for parametric variables and medians and interquartile ranges (IQRs) for nonparametric variables. Number of nocturnal awakenings and sleep efficiency were normally distributed, whereas sleep onset, sleep latency, WASO, awakening length, and sleep duration were not normally distributed. Student's t-test was used for age, number of awakenings, and sleep efficiency as parametric variables by child sex; Wilcoxon rank-sum test was used to test differences in nonparametric variables including sleep onset, sleep latency, WASO, awakening length, and sleep duration by child sex. Fisher's or χ^2 test was conducted to compare differences in sociodemographic factors, daytime napping, medication use, and disability groups by child sex. Analysis of variance or Kruskal-Wallis test was conducted to evaluate the differences in sleep parameters across children's disability groups and caregivers' education levels.

A general linear model was fitted to generate least-square means and standard errors (SEs) of sleep efficiency across caregivers' education levels with adjustment for children's age, sex, disability, caregiver-child relationship, and caregivers' age. Univariate and multivariable linear

regression analyses were performed to examine the associations of caregivers' education levels

with sleep efficiency and the number of awakenings. Stratified analysis was conducted to evaluate whether the associations between caregivers' education levels and children's sleep disturbances differed according to children's disability groups. Given that we aimed to examine whether children whose caregivers had lower education level were more likely to have sleep disturbances (e.g., long sleep latency, long WASO) and to enhance interpretability, we created categorical variables for these sleep parameters and used in logistic regression models. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using logistic regression models to evaluate the associations of caregivers' educational attainment with children's long sleep latency (≥ 30 vs. < 30 minutes), long WASO (≥ 90 vs. < 90 minutes), and short sleep duration (< 8 vs. ≥ 8 hours). These cut points were chosen based on the literature of sleep latency²⁵ and sleep duration,²⁶ as well as sleep data distributions in the study (WASO median=88 minutes, sleep duration median=8 hours; only 9.6% of children had sleep ≥ 9 hours). We also included a variable to represent study wave (I and II) in multivariable regression models and found similar results (data not shown). We conducted sensitivity analysis by including medication use and daytime napping in the models and did not find that they had an impact on our results in this study (data not shown). Statistical significance levels were set at $P < 0.05$ for two-sided analyses. P values were not corrected for multiple testing. All tests were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1 The mean age of children with disabilities was 9.2 (SD=2.2; range=6-12) years. Most caregivers
2 were mothers (88.0%); 21.6% of caregivers reported having <high school education level (**Table**
3 **1**). There were no statistically significant differences in medication use, daytime napping,
4 caregiver-child relationship, caregivers' age, employment status, or education level between
5 boys and girls.
6
7
8
9

10 Median time for sleep onset was 22:39, sleep latency 27.3 minutes, WASO 88.1 minutes, and
11 sleep duration 8.0 hours (**Table 1**). The mean number of awakenings was 22.1 and sleep
12 efficiency was 80.0%. There were no statistically significant differences in sleep parameters
13 between boys and girls (all P >0.05). Overall, 43.2% of children had sleep latency \geq 30 minutes,
14 51.2% had short sleep <8 hours, and 77.6% had low sleep efficiency <85%.
15
16
17
18
19
20
21
22
23
24
25
26

27 There were no significant differences in sleep parameters across disability groups
28 (**Supplementary Figure 1**), except for the number of nocturnal awakenings (**Supplementary**
29 **Table 1**). Children with diseases of musculoskeletal system and connective tissue, skin and
30 subcutaneous tissue appeared to have more awakenings, reflecting more fragmented sleep, than
31 children with other disabilities.
32
33
34
35
36
37
38
39
40

41 Children whose caregivers had <high school had longer sleep latency, longer WASO, longer
42 awakening length, and lower sleep efficiency compared to children whose caregivers had >high
43 school (**Figure 1, Table 2**). Although children of caregivers with <high school tended to have
44
45

46 For personal use only: <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

later sleep onset, higher number of awakenings, and shorter sleep duration when compared to children of caregivers with higher education, these differences did not reach statistical significance.

Our general linear model with adjustment for child age, sex, disability group, caregiver-child relationship, and caregiver age showed that the mean sleep efficiency was the lowest among children of caregivers with <high school (75.7% [SE=1.4]), followed by children of caregivers with high school (80.4% [SE=1.0]) and >high school (81.9% [SE=1.0]). Univariate and multivariable linear regression analyses showed no significant associations between caregivers' education levels and children's awakening number. However, compared to children whose caregivers had >high school, children of caregivers with <high school had significantly lower sleep efficiency (adjusted beta=-6.3, SE=1.7; P=0.001) (**Table 3**). Caregivers' educational attainment was positively and significantly associated with children's sleep efficiency in the univariate model ($P_{trend}=0.001$) and the multivariable model ($P_{trend}<0.001$).

As shown in **Table 4** based on logistic regression models, compared to children whose caregivers had >high school, children of caregivers with <high school had higher odds of longer sleep latency ≥ 30 minutes (adjusted OR=3.27; 95% CI=1.12-9.61) and longer WASO ≥ 90 minutes (OR=5.95; 95% CI=1.91-18.53). Caregivers' education levels were inversely and significantly associated with children's sleep latency and WASO (both $P_{trend}<0.05$). Children's

short sleep duration (<8 hours) was not associated with caregivers' low educational level (OR=0.78; 95% CI=0.28-2.18).

The associations between caregivers' education and children's sleep efficiency varied little according to disability groups (data not shown in tables). For example, among children with mental and behavioral disorders, children of caregivers with <high school had lower sleep efficiency (beta=-6.2, SE=2.2; P=0.006), after adjustment for children's age, sex, caregiver-child relationship, and caregivers' age. Similar results were found for children with other disabilities.

DISCUSSION

In this cross-sectional study, we assessed sleep patterns using wrist actigraphy over seven consecutive days among Chilean children with disabilities. We found that actigraphy-measured sleep disturbances including long sleep latency (median=27 minutes), long WASO (median=88 minutes), short sleep duration (median=8 hours), high number of nocturnal awakenings (mean=22), and low sleep efficiency (mean=80%) were common among children. These findings indicate that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency) and maintaining sleep (long WASO, low sleep efficiency), and have increased sleep fragmentation (increased nocturnal awakenings). These indices are common in insomnia, which may occur secondary to chronic health conditions, and for many conditions, is associated with poor quality of life and increased disease-specific health burden including

behavioral and cognitive problems.^{27, 28} We also found strong associations between caregivers'

low educational attainment and children's sleep disturbances (e.g., low sleep efficiency)

independent of children's disability type and other covariates from both children and caregivers.

To our knowledge, this is the first study to specifically quantify actigraphy-measured sleep

patterns among children with disabilities in relation to caregivers' education levels. Furthermore,

we address these questions among Patagonian Chilean children with disabilities, an understudied

population in South America.

Children with a wide range of disabilities have been reported to have sleep disturbances,

including prolonged sleep latency, increased WASO, short sleep duration, and decreased sleep

efficiency in Europe and other developed countries including Canada and New Zealand.^{4-6, 29, 30}

For example, in a small study of 8 UK children with mucopolysaccharidosis aged 2-15 years,

median actigraphy-measured sleep latency was 35.4 minutes, WASO 83.4 minutes, and sleep

efficiency was 75.6%.³⁰ Allik et al reported that children aged 8-12 years with Asperger

syndrome and high-functioning autism in Sweden had actigraphy-measured longer sleep latency

(mean=32 minutes) and lower sleep efficiency (mean=87%) than controls.⁶ In a study of children

aged 5-11 years with ADHD in Denmark, average sleep latency was 26 minutes and 31% of

children had sleep latency >30 minutes.⁵ A case-control study using 5 nights of actigraphy for 15

school-aged children with traumatic brain injury and 15 school-aged siblings in the UK reported

that brain injury was significantly associated with children's longer sleep latency (mean=50

minutes), longer WASO (mean=65 minutes), and lower sleep efficiency (mean=80%).²⁹ To our

knowledge, no research has been conducted on objectively measured sleep parameters in South

America (e.g., Chile) among children with disabilities, an understudied sample. In our study of Chilean children with autism and other disabilities, the median of actigraphy-measured sleep latency was 27 minutes, WASO was 88 minutes, and the mean of sleep efficiency was 80%, which were similar to previous research findings.^{5, 29, 30} We also found that a high proportion of Chilean children with disabilities experienced actigraphy-measured sleep disturbances: 43% of children had sleep latency ≥ 30 minutes, 51% had short sleep < 8 hours (90% of children had sleep duration < 9 hours), and 78% had sleep efficiency $< 85\%$. Although school-aged children are recommended to have at least 9 hours of sleep,^{26, 31} in our study, only 10% of Chilean children with disabilities had sleep duration ≥ 9 hours. Gibbs et al reported that among 8 children aged 4-15 years with Prader-Willi syndrome in New Zealand, median 7-night actigraphy-measured WASO was 95 minutes.³² Corkum et al reported the average of awakenings was 15 among Canadian children with ADHD (aged 7-11 years).⁴ In our current study, the average number of nocturnal awakenings was 22 among Chilean children with ADHD and other disabilities. Our study along with previous research suggests that children with disabilities have difficulties initiating and maintaining good sleep.

Several researchers have reported that children with disabilities have late sleep onset.^{33, 34} A study of US children aged 2-5 years with autism and other developmental disabilities reported that the mean of 7-day actigraphy-measured sleep onset time was 21:32.³³ In this study, we found that median sleep onset time was 22:39 among Chilean children with autism and other

disabilities. Unique climate (e.g., late sunset) and lifestyle characteristics (e.g., late mealtime) in

1 the Patagonia region may have partly contributed to children's late sleep onset time.^{13,18} Our
2 findings of late sleep onset are generally consistent with literature for children in this age range.
3 For example, a cross-sectional study of 96 healthy Chilean children aged 10 years found that the
4 mean of overnight polysomnography-measured sleep onset time was 23:10 for children with
5 normal weight and 23:20 for children with overweight and obesity.³⁵ Another study of 58 healthy
6 children aged 11-13 years in the US showed that the mean of 4-day actigraphy-measured sleep
7 onset time was 23:27.³⁶ In the Cleveland Children's Sleep and Health Study, 14.8% of US
8 children aged 8-11 years had bedtime 23:00 or later.¹⁴ Future research is warranted to examine
9 potential risk factors of late bedtime such as daytime napping and how to improve sleep onset
10 time among children with disabilities.
11
12
13
14
15
16
17
18
19
20
21
22
23
24

25 It has been reported that children whose caregivers have low education levels are more likely to
26 have adverse health outcomes, such as great body weight¹⁶ and poor quality of life.¹⁷ McDonald
27 et al found that lower maternal education was independently associated with parent-reported
28 shorter sleep (<11 hours/night) among young children.¹² Although several studies have reported
29 that parental education is associated with child health,^{12,15} we are unaware of published reports
30 that have investigated whether and how caregivers' education levels are related to objectively
31 measured sleep problems among children with disabilities. In our study, caregivers' education
32 level in relation to children's sleep disturbances was substantiated through statistically
33 significant association as shown in univariate and multivariable linear and logistic regression
34
35
36
37
38
39
40
41
42
43
44
45

46 For peer review only. This document is copyrighted by the British Medical Journal. For personal use only: <http://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

educational attainment to improve children's sleep health. We considered low educational attainment a proxy for low socioeconomic status (SES). It has been reported that educational levels and SES are highly correlated.³⁷ Low SES, as well as low education, has been related to high risk for cardiovascular disease, cancer, and mortality.³⁸ Parental SES has been inversely associated with negative child health outcomes including cardiovascular disease and mortality.³⁹

⁴⁰ Some of the burden from low parental education level may be attributable to relatively lower health literacy, particularly sleep health literacy, which is pertinent to our observations in the focus group study¹³ and also in this epidemiologic study.

Parents with low education levels may lack knowledge and resources about children's sleep practices and disabilities, resulting in adverse parenting practices known to affect sleep hygiene such as less limit setting, more variability in routines important to establish regular sleep patterns, suboptimal configuration of bedrooms to optimize sleep, inappropriate use of electronic devices, and meal timing in relationship to sleep. Better-educated parents may have more access to information about sleep and disabilities possibly through the internet or group membership with other parents of children diagnosed with disabilities. Future research should consider the impact of providing education and support such as sleep hygiene education, as well as initiatives to provide social support for parents and families of children with disabilities. Although our data suggest that these efforts may especially benefit less well-educated parents, all parents may have difficulties in navigating all of the controversies and different claims on the internet and may

benefit from improved education and support. Our findings of the associations documented in

For peer review only: <https://bmjopen.bmj.com/> on April 20, 2024 by guest. Protected by copyright.

our study population, if replicated, could help motivate the development and implementation of training programs to increase the parental health literacy (especially sleep health literacy). Parents of children with disabilities could benefit from sleep education workshops. Social support from families of children with disabilities as well as health care providers including occupational and physiotherapists and nurses could also be important in helping parents handle with their children's sleep problems.

Lack of knowledge of healthy sleep behaviors among caregivers has been associated with an increased risk of having unhealthy sleep behaviors for their children.⁴¹ Although sleep disturbances have been noted to be common in children with neurological conditions (e.g., cerebral palsy), there are no interventions specifically designed to improve sleep in these children.⁴² Several small studies of children with ASD have reported that parent-based sleep education appears effective in improving child sleep health.^{34, 43} For example, a study of 20 children with ASD showed that parent-based sleep education workshops improved sleep latency from 62.2 minutes to 45.6 minutes.⁴³ Malow et al reported that sleep education to parents of 80 children with ASD (aged 2-10 years) significantly decreased children's sleep latency from 58.2 to 39.6 minutes.³⁴ Our prior qualitative study in Chile has indicated that parental knowledge gaps regarding healthy sleep behaviors in children support the need for increased sleep health education among targeted caregivers.¹³ Pediatricians and family physicians can be trained to provide adequate advice and educational messages (e.g., sleep health) to pediatric patients and their families.⁴⁴

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1 Our study has several limitations. First, we did not have a comparison group of children without
2 disabilities. Second, this study was limited by its modest sample size and the heterogeneity of
3 disabilities represented among children studied. As such, the confidence intervals were wider for
4 some groups (e.g., the less than high school education group) and we were not able to report
5 associations specific to any single disability category (e.g., autism). Third, we did not collect
6 information pertaining to some aspects of sleep which may be associated with low education
7 levels such as caregivers' shift work, sleep hygiene, and other factors such as co-sleeping, lack of
8 knowledge about sleep health, or inability to obtain medications to treat sleep or conditions in
9 this study. Hence we were not able to quantify the influence of these factors on children's sleep
10 patterns. Our findings also focused on caregivers (majority were mothers) of children with
11 disabilities in Chile, and may not be generalizable to other populations/groups. Although
12 accepted to provide an objective measure of sleep-wake cycle, actigraphy has its limitations. For
13 example, periods of quiet wakefulness may be interpreted by the device as sleep, and periods of
14 restless sleep may be interpreted by the device as wakefulness.^{8, 45} Recent literature has indicated
15 limitations of actigraphy for accurately capturing children's awakenings.⁴⁶ Our study has
16 indicated that children with diseases of the musculoskeletal system and connective, skin, and
17 subcutaneous tissue have more awakenings because their restless sleep may be represented by
18 actigraphy as awakenings, and/or due to medication use or body pain. Despite this, actigraphy
19 has been well validated for objective estimation of nocturnal sleep parameters across age groups
20 in the natural sleep environment.⁹ As this was an exploratory study that aimed to examine

21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46 For peer review only
47
48
49

whether parental education was associated with children's sleep disturbances, we did not adjust for multiple comparisons in this study. In addition, the simple adjustments for multiple comparisons might be overly conservative because many sleep problems (e.g., long WASO, low sleep efficiency) were correlated.

CONCLUSIONS

We were successful in using wrist-actigraphy as a means of collecting objective measures of sleep patterns among Chilean Patagonian children with disabilities (e.g., 97.6% of children completed the 7-day data collection protocol). Using collected data, we noted that children with disabilities frequently experience difficulties initiating sleep (prolonged sleep latency), maintaining sleep (long WASO, low sleep efficiency), and sleep fragmentation (increased nocturnal awakenings). Among children with disabilities, lower levels of caregivers' educational attainment are strongly associated with children's sleep disturbances and these associations appear to be independent of children's age, sex, disability group, caregiver-child relationship, and caregiver age. Parental support and education programs directed to families with low education levels may be of particular importance for sleep behavior intervention among children with disabilities. Larger studies, using wrist-actigraphy methods to objectively measure sleep in this relatively understudied population, are warranted to confirm our findings. Future research is also needed regarding the effects of sleep education intervention as well as social support to low educational families of children with disabilities on sleep health, with taking into account of different cultural backgrounds.

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

Contributors' Statement

1 All of the authors have agreed to the content of this manuscript. XC conceptualized and
2
3 designed the study, supervised data collection, carried the initial analyses, and drafted the initial
4
5 manuscript. JCV and CB carried out the field survey, supervised data collection, and critically
6
7 reviewed and revised the manuscript. MP carried out the field survey, coordinated data collection
8
9 at the study site, and reviewed the manuscript. BG helped develop the study protocol, and
10
11 critically reviewed and revised the manuscript. SR critically reviewed and revised the
12
13 manuscript. MAW provided funding support to the study, supervised the study, conceptualized
14
15 and designed the study, and critically reviewed and revised the manuscript.
16
17
18
19
20
21

22
23 **Competing Interests:** The authors have no competing interests to disclose. The authors alone
24
25 are responsible for the content and writing of the paper.
26
27
28

29
30 **Funding Support:** This research was supported by awards from the National Institutes of Health
31
32 (National Institute on Minority Health and Health Disparities: T37-MD001449), the National
33
34 Center for Research Resources (NCRR), the National Center for Advancing Translational
35
36 Sciences (NCATS: 8UL1TR000170-07), and the Rose Traveling Award.
37
38
39

40
41 **Ethics Approval:** This study was approved by the institutional review boards of the Centro de
42
43 Rehabilitacion Club de Leones Cruz del Sur and Harvard T.H. Chan School of Public Health
44
45

Data Sharing Statement: No additional data are available.

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

REFERENCES

1. World report on disability 2011. World Health Organization.
<http://www.who.int/disabilities/>. Accessed October 20, 2014
2. Churchill SS, Kieckhefer GM, Landis CA, Ward TM. Sleep measurement and monitoring in children with Down syndrome: A review of the literature, 1960-2010. *Sleep Med Rev.* 2012;16(5):477-488
3. Sung V, Hiscock H, Sciberras E, Efron D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the child and family. *Arch Pediatr Adolesc Med.* 2008;162(4):336-342
4. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). *Sleep.* 2001;24(3):303-312
5. Hvolby A, Jorgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med.* 2008;162(4):323-329
6. Allik H, Larsson JO, Smedje H. Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *J Autism Dev Disord.* 2006;36(5):585-595
7. Sekine M, Chen X, Hamanishi S, Wang H, Yamagami T, Kagamimori S. The validity of sleeping hours of healthy young children as reported by their parents. *J Epidemiol.* 2002;12(3):237-242

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

8. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev.* 2002;6(2):113-124
9. Martin JL, Hakim AD. Wrist actigraphy. *Chest.* 2011;139(6):1514-1527
10. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcantara C, et al. Racial/Ethnic differences in sleep disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA). *Sleep.* 2015;38(6):877-888
11. Mezick EJ, Matthews KA, Hall M, Strollo PJ, Jr., Buysse DJ, Kamarck TW, et al. Influence of race and socioeconomic status on sleep: Pittsburgh Sleep SCORE project. *Psychosom Med.* 2008;70(4):410-416
12. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter sleep in early childhood. *Sleep Med.* 2014;15(5):536-540
13. Chen X, Gelaye B, Velez JC, Pepper M, Gorman S, Barbosa C, et al. Attitudes, beliefs, and perceptions of caregivers and rehabilitation providers about disabled children's sleep health: a qualitative study. *BMC Pediatr.* 2014;14:245
14. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner HL, Redline S. Effects of the home environment on school-aged children's sleep. *Sleep.* 2005;28(11):1419-1427
15. Magana S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services among latino children with autism spectrum disorders. *Intellec Dev Disabil.* 2013;51(3):141-153

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
16. Cameron AJ, van Stralen MM, Brug J, Salmon J, Bere E, Chinapaw MJ, et al. Television in the bedroom and increased body weight: potential explanations for their relationship among European schoolchildren. *Pediatr Obes*. 2013;8(2):130-141
 17. Kumar S, Kroon J, Laloo R. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Health Qual Life Outcomes*. 2014;12:41
 18. Velez JC, Fitzpatrick AL, Barbosa CI, Diaz M, Urzua M, Andrade AH. Nutritional status and obesity in children and young adults with disabilities in Punta Arenas, Patagonia, Chile. *Int J Rehabil Res*. 2008;31(4):305-313
 19. International Classification of Functioning, Disability and Health (ICF). <http://www.who.int/classifications/icf/en/>. Accessed July 16, 2015
 20. Chen X, Gelaye B, Velez JC, Barbosa C, Pepper M, Andrade A, et al. Caregivers' hair cortisol: A possible biomarker of chronic stress is associated with obesity measures among children with disabilities. *BMC Pediatr*. 2015;15:9
 21. Chen X, Velez JC, Barbosa C, Pepper M, Andrade A, Stoner L, et al. Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress*. 2015;18(1):20-28
 22. ActiLife 6. ActiLife, ActiGraph R&D. <http://www.theactigraph.com/products/actisleep/>. Accessed November 12, 2014

23. International Classification of Diseases (ICD-10). ICD-10 International Statistical Classification of Diseases and Related Health Problems. 10th Revision. Volume 2. Instruction manual Published 2010
24. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Wolfson AR, Hafer A, et al. Estimating sleep patterns with activity monitoring in children and adolescents: how many nights are necessary for reliable measures? *Sleep*. 1999;22(1):95-103
25. Adkins KW, Molloy C, Weiss SK, Reynolds A, Goldman SE, Burnette C, et al. Effects of a standardized pamphlet on insomnia in children with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S139-144
26. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity (Silver Spring)*. 2008;16(2):265-274
27. Lipton J, Becker RE, Kothare SV. Insomnia of childhood. *Curr Opin Pediatr*. 2008;20(6):641-649
28. Malow BA, Byars K, Johnson K, Weiss S, Bernal P, Goldman SE, et al. A practice pathway for the identification, evaluation, and management of insomnia in children and adolescents with autism spectrum disorders. *Pediatrics*. 2012;130 Suppl 2:S106-124
29. Sumpter RE, Dorris L, Kelly T, McMillan TM. Pediatric sleep difficulties after moderate-severe traumatic brain injury. *J Int Neuropsychol Soc*. 2013;19(7):829-834
30. Mahon LV, Lomax M, Grant S, Cross E, Hare DJ, Wraith JE, et al. Assessment of sleep in children with mucopolysaccharidosis type III. *PloS One*. 2014;9(2):e84128

31. The National Sleep Foundation/<http://sleepfoundation.org/>. Accessed October 12, 2014

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
32. Gibbs S, Wiltshire E, Elder D. Nocturnal sleep measured by actigraphy in children with Prader-Willi syndrome. *J Pediatr*. 2013;162(4):765-769
33. Goodlin-Jones BL, Tang K, Liu J, Anders TF. Sleep patterns in preschool-age children with autism, developmental delay, and typical development. *J Am Acad Child Adolesc Psychiatry*. 2008;47(8):930-938
34. Malow BA, Adkins KW, Reynolds A, Weiss SK, Loh A, Fawkes D, et al. Parent-based sleep education for children with autism spectrum disorders. *J Autism Dev Disord*. 2014;44(1):216-228
35. Chamorro R, Algarin C, Garrido M, Causa L, Held C, Lozoff B, et al. Night time sleep macrostructure is altered in otherwise healthy 10-year-old overweight children. *Int J Obes (Lond)*. 2014;38(8):1120-1125
36. Holm SM, Forbes EE, Ryan ND, Phillips ML, Tarr JA, Dahl RE. Reward-related brain function and sleep in pre/early pubertal and mid/late pubertal adolescents. *J Adolesc Health*. 2009;45(4):326-334
37. Cassidy A, Drotar D, Ittenbach R, Hottinger S, Wray J, Wernovsky G, Newburger JW, Mahony L, Mussatto K, Cohen MI, Marino BS. The impact of socioeconomic status on health related quality of life for children and adolescents with heart disease. *Health Qual Life Outcomes*. 2013;11:99
38. Vathesatogkit P, Batty GD, Woodward M. Socioeconomic disadvantage and disease-specific mortality in Asia: systematic review with meta-analysis of population-based

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
39. Ebrahim S, Montaner D, Lawlor DA. Clustering of risk factors and social class in childhood and adulthood in British women's heart and health study: cross sectional analysis. *BMJ*. 2004; 328(7444):861
40. Kim J, Son M. The extent and distribution of inequalities in childhood mortality by cause of death according to parental socioeconomic positions: a birth cohort study in South Korea. *Soc Sci Med*. 2009;69(7):1116-1126
41. Owens JA, Jones C, Nash R. Caregivers' knowledge, behavior, and attitudes regarding healthy sleep in young children. *J Clin Sleep Med*. 2011;7(4):345-350
42. Galland BC, Elder DE, Taylor BJ. Interventions with a sleep outcome for children with cerebral palsy or a post-traumatic brain injury: a systematic review. *Sleep Med Rev*. 2012;16(6):561-573
43. Reed HE, McGrew SG, Artibee K, Surdkya K, Goldman SE, Frank K, et al. Parent-based sleep education workshops in autism. *J Child Neurol*. 2009;24(8):936-945
44. Halal CS, Nunes ML. Education in children's sleep hygiene: which approaches are effective? A systematic review. *J Pediatr*. 2014;90(5):449-456
45. Johnson KP, Giannotti F, Cortesi F. Sleep patterns in autism spectrum disorders. *Child Adolesc Psychiatr Clin N Am*. 2009;18(4):917-928
46. Meltzer LJ, Walsh CM, Traylor J, Westin AM. Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep*. 2012;35(1):159-166

Figure 1 Children’s Sleep Parameters, by Caregiver Education Levels (HS: high school)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

For peer review only

Table 1 Characteristics of Children with Disabilities and Their Primary Caregivers

| | Total | Boys | Girls |
|---------------------------------------|----------------------|----------------------|----------------------|
| | (n=125) | (n=69) | (n=56) |
| Characteristics | | | |
| Age at onset (SD), years | 9.2 (2.2) | 8.8 (2.1) | 9.8 (2.3) |
| Percentage of disability diagnosis, % | | | |
| Autism and behavioral disorders | 48.0 | 59.4 | 33.9 |
| Diseases of musculoskeletal system | 16.8 | 10.1 | 25.0 |
| Diseases of the nervous system | 27.2 | 27.5 | 26.8 |
| Genital/chromosomal abnormalities | 8.0 | 2.9 | 14.3 |
| Sleep apnoea | 16.8 | 14.5 | 19.6 |
| Tobacco use | 44.0 | 42.0 | 46.4 |
| Parameters | | | |
| Age at onset, median (IQR) | 22:39 (22:06, 23:08) | 22:44 (22:24, 23:08) | 22:33 (21:54, 23:09) |
| Age at latency, median (IQR), minutes | 27.3 (15.0, 38.9) | 27.1 (14.4, 41.7) | 27.4 (15.4, 38.2) |
| Age at AS, median (IQR), minutes | 88.1 (65.6, 111.1) | 92.4 (64.4, 112.4) | 81.9 (66.2, 107.0) |

| | | | | |
|----|--|----------------|----------------|----------------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | number of awakenings, mean (SD) ^a | 22.1 (6.7) | 22.5 (6.5) | 21.6 (6.9) |
| 5 | | | | |
| 6 | wakening length, median (IQR), minutes | 5.1 (4.2, 7.1) | 5.1 (4.2, 7.0) | 5.1 (4.2, 7.1) |
| 7 | | | | |
| 8 | sleep duration, median (IQR), hours | 8.0 (7.5, 8.2) | 8.0 (7.3, 8.2) | 8.0 (7.5, 8.3) |
| 9 | | | | |
| 10 | sleep efficiency, mean (SD), % ^a | 80.0 (7.2) | 79.0 (8.1) | 81.2 (5.8) |
| 11 | | | | |
| 12 | giver characteristics | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | age, mean (SD), years | 38.3 (7.8) | 38.5 (7.8) | 38.0 (7.8) |
| 16 | | | | |
| 17 | | | | |
| 18 | giver-child relationship, % | | | |
| 19 | | | | |
| 20 | with mother | 88.0 | 88.4 | 87.5 |
| 21 | | | | |
| 22 | with father | 12.0 | 11.6 | 12.5 |
| 23 | | | | |
| 24 | employed/self-employed | 60.0 | 62.3 | 57.1 |
| 25 | | | | |
| 26 | | | | |
| 27 | education level, % | | | |
| 28 | | | | |
| 29 | high school | 21.6 | 24.6 | 17.9 |
| 30 | | | | |
| 31 | high school | 37.6 | 29.0 | 48.2 |
| 32 | | | | |
| 33 | high school | 40.8 | 46.4 | 33.9 |
| 34 | | | | |
| 35 | | | | |

36 Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

1
2
3 Of these sleep parameters, only number of awakenings and sleep efficiency were normally distributed (Kolmogorov-
4
5 Smirnov test: $P > 0.05$). While Student's t-test was used for number of awakenings and sleep efficiency, Wilcoxon rank-
6
7 sum test was used for the other sleep parameters.
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3 **Table 2** Children's Sleep Parameters, By Caregivers' Education Levels
4
5

| Parameters | <High school (n=27) | High school (n=47) | >High school (n=51) |
|--|------------------------|-----------------------|------------------------|
| onset, median (IQR) | 23:05 (22:17, 23:23) | 22:31 (21:55, 23:04) | 22:39 (22:24, 23:02) |
| latency, median (IQR), minutes | 35.6 (17.3, 53.7) | 27.1 (17.4, 38.4) | 23.6 (11.1, 35.9) |
| Onset, median (IQR), minutes | 99.1 (88.1, 121.0) | 77.1 (63.4, 103.4) | 77.0 (57.6, 106.0) |
| Number of awakenings, mean (SD) ^a | 23.1 (5.7) | 21.2 (6.3) | 22.4 (7.5) |
| Awakening length, median (IQR), minutes | 6.9 (5.0, 9.5) | 5.2 (4.2, 7.2) | 4.7 (3.9, 5.7) |
| Duration, median (IQR), hours | 7.9 (7.3, 8.4) | 8.0 (7.6, 8.2) | 8.0 (7.4, 8.2) |
| efficiency, mean (SD), % ^a | 75.9 (7.0) | 80.5 (7.3) | 81.8 (6.5) |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

Sleep efficiency and number of awakenings were normally distributed in this study.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60**Table 3** Linear Regression Models for Associations between Caregiver Education and Child Sleep Parameters

| | Number of awakenings | | Sleep efficiency (%) | |
|---|-------------------------------|---------|----------------------|------------------|
| | Beta (SE) | P value | Beta (SE) | P value |
| Univariate model | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -1.2 (1.3) | 0.384 | -1.3 (1.4) | 0.357 |
| <High school | 0.7 (1.6) | 0.662 | -5.9 (1.7) | <0.001 |
| | <i>P value for trend test</i> | | | <i>0.001</i> |
| Multivariable model^a | | | | |
| Caregiver education (ref: >high school) | | | | |
| High school | -0.6 (1.4) | 0.674 | -1.6 (1.4) | 0.269 |
| <High school | 1.9 (1.7) | 0.245 | -6.3 (1.7) | 0.001 |
| | <i>P value for trend test</i> | | | <i><0.001</i> |

Abbreviation: SE, standard error.

^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

1
2
3 **Table 4** Logistic Regression Models for Associations between Caregiver Education and Child Sleep Disturbances
4
5

| | Sleep latency ≥ 30 | | WASO ≥ 90 | | Sleep duration ≥ 8 |
|--|-------------------------|---------|--------------------|---------|-------------------------|
| | vs. < 30 minutes | | vs. < 90 minutes | | vs. ≥ 8 hours |
| | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) |
| crude model | | | | | |
| higher education (ref: $>$ high school) | | | | | |
| high school | 0.95 (0.42, 2.17) | 0.911 | 1.36 (0.61, 3.04) | 0.449 | 0.72 (0.33, 1.60) |
| high school | 3.37 (1.26, 8.98) | 0.015 | 4.43 (1.58, 12.38) | 0.005 | 0.89 (0.35, 2.25) |
| <i>P</i> value for trend test | | 0.029 | | 0.006 | |
| adjusted model | | | | | |
| higher education (ref: $>$ high school) ^a | | | | | |
| high school | 1.02 (0.42, 2.45) | 0.966 | 1.38 (0.58, 3.30) | 0.468 | 0.70 (0.30, 1.64) |
| high school | 3.27 (1.12, 9.61) | 0.031 | 5.95 (1.91, 18.53) | 0.002 | 0.78 (0.28, 2.18) |
| <i>P</i> value for trend test | | 0.056 | | 0.004 | |

37 Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; WASO, wake after sleep onset.

38
39 ^aAdjusted for child age, sex, disability, caregiver-child relationship, and caregiver age.

Figure 1 Children's Sleep Parameters, by Caregiver Education Levels (HS: high school)

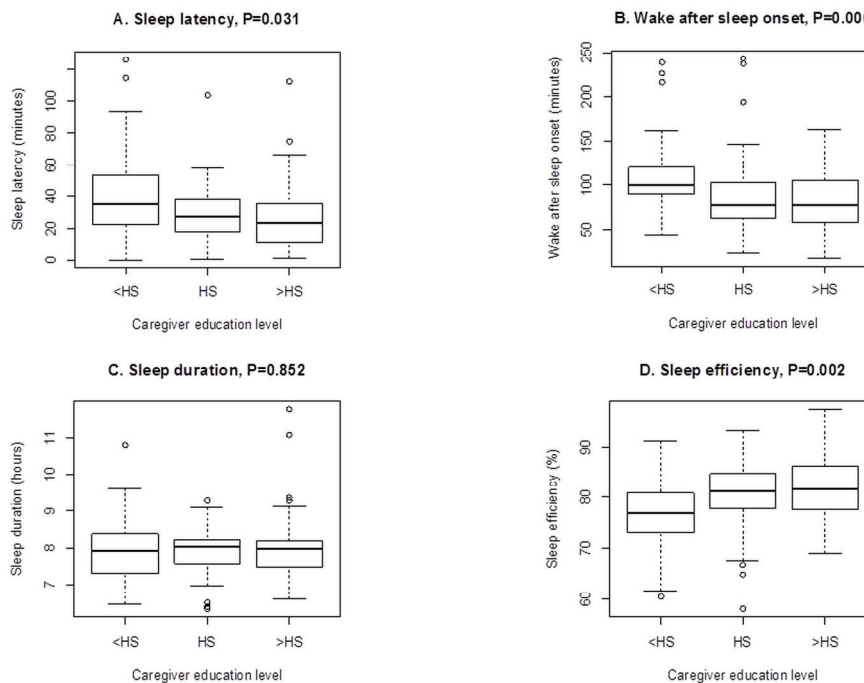


Figure in TIFF format
190x142mm (300 x 300 DPI)

View only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Supplementary Table 1 Children's Sleep Parameters, By Types of Disability Diagnoses

| Sleep parameters | Diagnosis I (n=60) | Diagnosis II (n=21) | Diagnosis III (n=34) | Diagnosis IV (n=10) | P value |
|--|-----------------------|------------------------|-------------------------|------------------------|------------|
| Sleep onset, median (IQR) | 22:35 (22:04, 23:03) | 23:05 (22:25, 23:22) | 22:37 (22:19, 23:05) | 22:35 (21:45, 23:03) | 0.187 |
| Sleep latency, median (IQR), minutes | 24.1 (14.7, 40.1) | 28.1 (22.1, 43.0) | 28.8 (14.1, 38.4) | 30.5 (9.1, 39.4) | 0.804 |
| WASO, median (IQR), minutes | 78.4 (63.5, 104.9) | 103.3 (75.0, 123.7) | 89.1 (61.7, 100.0) | 94.0 (69.9, 117.9) | 0.252 |
| Number of awakenings, mean (SD) ^a | 22.4 (6.6) | 25.1 (5.1) | 19.3 (6.5) | 23.6 (7.6) | 0.011 |
| Sleep duration, median (IQR), hours | 8.0 (7.7, 8.3) | 7.6 (7.0, 8.0) | 8.0 (7.4, 8.3) | 8 (7.1, 8.5) | 0.138 |
| Sleep efficiency, mean (SD), % ^a | 81.2 (6.5) | 78.2 (6.2) | 79.5 (8.6) | 78.3 (8.2) | 0.309 |

Abbreviations: IQR, interquartile range; SD, standard deviation; WASO, wake after sleep onset.

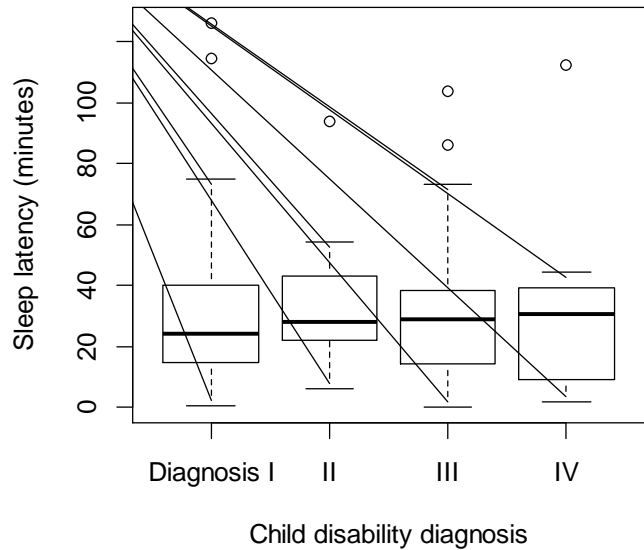
Only sleep efficiency (%) and number of awakenings were normally distributed (Kolmogorov-Smirnov test: $p > 0.05$).

^aAnalysis of variance was used for sleep efficiency and number of awakenings (normally distributed), while Kruskal-Wallis test was used for other sleep parameters.

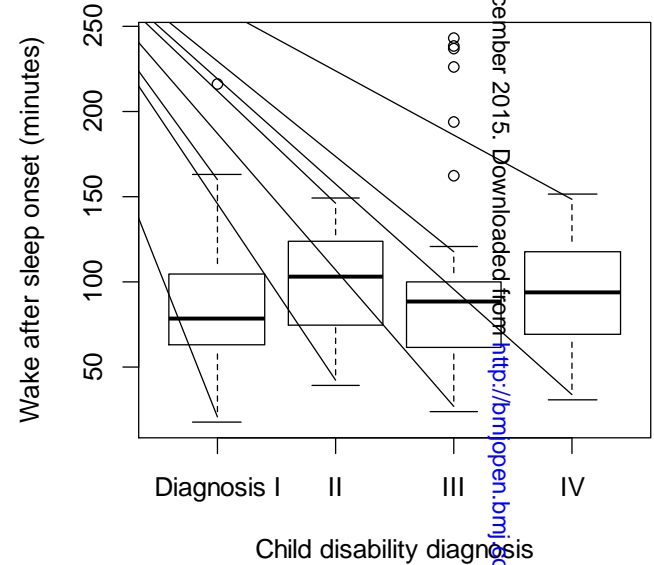
Diagnosis I: mental and behavioral disorders (e.g., autism, ADHD, mental retardation); Diagnosis II: disease of the musculoskeletal system and connective tissue, skin and subcutaneous tissue (e.g., scoliosis); Diagnosis III: diseases of the nervous system (e.g., cerebral palsy); Diagnosis IV: congenital malformations, deformations and chromosomal abnormalities (e.g. Down syndrome).

Supplementary Figure 1 Children's Sleep Parameters, by Disability Diagnoses

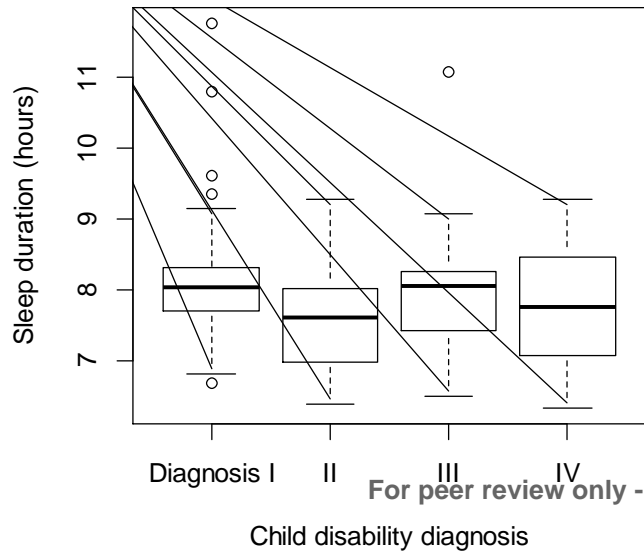
A. Sleep latency, P=0.804



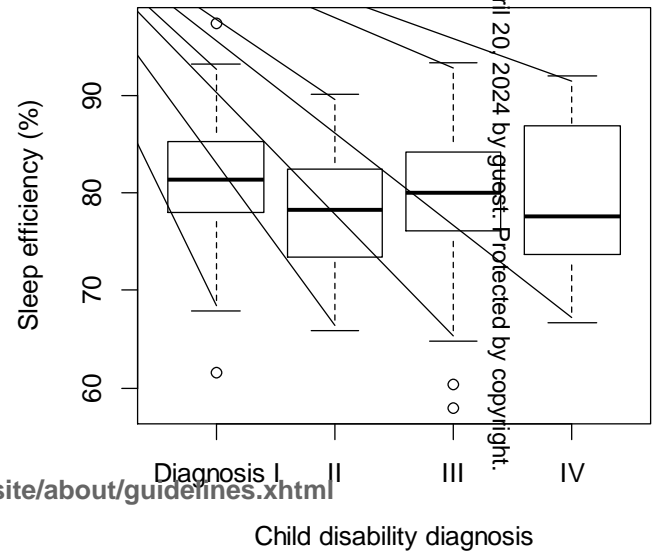
B. Wake after sleep onset, P=0.252



C. Sleep duration, P=0.138



D. Sleep efficiency, P=0.309



0855 on 7 December 2015. Downloaded from <http://bmjopen.bmj.com/> by guest. Protected by copyright. April 20, 2024

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|------------------------------|---------|---|
| Title and abstract | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including hypotheses |
| Methods | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (a) <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement). |
| Bias | 9 | |
| Study size | 10 | This is a cross-sectional, pilot study. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions |
| Results | | |
| Participants | 13 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| Descriptive data | 14 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| Outcome data | 15 | <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

Discussion

| | | |
|------------------|----|--|
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |

Other information

| | | |
|---------|----|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study. |
|---------|----|---|

For peer review only