Concordance in caregiver and child sleep health metrics among families experiencing socioeconomic disadvantage: A pilot study

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Acknowledgements

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Introduction

Approximately 90% of children obtain less sleep than recommended.[1] Poor sleep health (eg, short sleep duration, late sleep timing)[2] in children is associated with a myriad of negative cognitive (eg, impaired executive functioning), affective (eg, negative mood), physiological (eg, increased cardiometabolic risk), and behavioral (eg, substance use) effects that substantially impair health, well-being, and thriving.[3-6] Insufficient sleep in childhood predicts insufficient sleep in later years, and contributes to an escalating risk of poor health outcomes across the life course.[7,8] Alarmingly, the negative effects of poor sleep health are disproportionately experienced in children born into families experiencing low socioeconomic status (SES; ie, low income, low caregiver educational attainment, lack of resources).[9,10] Addressing poor sleep health in children, particularly those living in low SES households,[11] represents an unmet public health need[12] that could advance efforts to ameliorate health disparities.[13]

Social Ecological[14] and Family Systems Frameworks[15] describe how important the family context and, specifically, parents are to shaping child health behaviors. For example, in the context of children's diet and physical activity behaviors, better parental dietary quality and higher engagement in physical activity are associated with better dietary intake and greater physical activity, respectively, in children.[16,17] In the context of sleep health, studies show sleep patterns (ie, bed and wake times) to co-occur between parents and their children in economically advantaged[18,19] and clinical[20] samples. However, these findings may not be generalizable to families experiencing socioeconomic disadvantage, where multilevel socio-ecological factors may interfere with the ability of children and parents to obtain adequate sleep health, and the extent to which their sleep patterns co-occur.[21,22] For example, parents may work multiple jobs or shift work, limiting their ability to go to bed at a reasonable time and have a consistent sleep schedule.[21] Furthermore, if parents are working during the child's bedtime, they will not be able to provide a structured, down-regulating routine (eg, teeth brushing, bath, reading)[23] necessary for adequate sleep duration and quality in children; nor will they be able to go to bed around the same time as their child, perhaps leading to lack of concordant sleep time between the dyad (parent + child).[21,24,25] Similarly, in disadvantaged families, family structures may be more complex.[26] Such homes are often multigenerational, and the biological parent may not be the primary caregiver responsible for the child's sleep.[27] Or it may be a single-parent household with limited social and family support, potentially limiting a parent's ability to prioritize healthy sleep patterns for themselves and their

child.[28]

Prior to developing family-based sleep health interventions that target both child and parent sleep behaviors, similar to other family-based health behavior interventions (ie, diet, physical activity),[29] it is necessary to examine these dyadic sleep relationships within the disadvantaged family context.[22,30] Thus, the aim of this pilot study is to characterize actigraphy-assessed sleep health (ie, sleep duration, midpoint, bedtime, and sleep efficiency), and to examine the level of concordance in sleep health metrics among disadvantaged caregiver-child dyads.

Methods

Study Design and Participants

This was a micro-longitudinal study, with data collected over 14 consecutive days. Caregiver-child dyads were recruited from two study sites: (1) Temple University Hospital in Philadelphia, Pennsylvania, and (2) the University of Delaware in Newark, Delaware. The Philadelphia cohort was recruited through a larger parent study examining sleep, smoking, and lung health disparities in older African American adults (ages 40-65 years). In this "parent" trial, participants who lived with children ages 6-14 years were invited to complete eligibility screening for this pilot study. The Delaware cohort was recruited through general media (eg, flyers) and advertisements posted in venues serving low-income communities (eg, food pantries, churches).

Caregivers in the Philadelphia cohort were deemed eligible if they self-reported: (1) being the primary caregiver of the child, (2) sleeping in the same house as the child $\geq$4 nights/week, (3) no moderate-severe sleep disorders or use of sleep medication, and (4) communicated in English. Caregivers in the Delaware cohort were eligible if they met those 4 criteria and additionally qualified for government-funded food assistance programs (ie, food stamps, WIC or SNAP benefits). Children at both sites were eligible if they: (1) were between 6-14 years of age, (2) slept in the same house as the adult caregiver $\geq$4 nights/week, (3) did not have a self-reported untreated sleep disorder, take sleep medication, or, (4) have a medical condition that may affect sleep patterns (eg, autism). If there was more than one child who fit the eligibility criteria in the home, all were invited to participate. Eligible dyads scheduled baseline assessments at their respective study site. This study was approved by the Temple University and University of Delaware Institutional Review Boards.

Data Collection

Primary caregivers attended a 30-minute baseline assessment where they completed written Informed consent and self-report assessments. Specifically, caregivers reported on demographics (ie, age, sex, race, education level, caregiver status) for themselves and their child(ren). Research personnel explained sleep diary and actigraphy protocols. The primary caregiver received the study equipment for themselves and their child(ren). Child assent for participation was obtained via phone later that evening.

      Caregiver-child dyads simultaneously wore an Actigraph wGT3X-BT continuously for 14 consecutive days on their nondominant wrist between April 2019 and March 2020. Data were collected in 1-minute epochs in the proportional integration mode. Actigraphy estimated the following sleep health metrics: (1) *sleep duration*: amount of sleep occurring between bedtime and waketime overnight, (2) *sleep efficiency*: percentage of time in bed that one is asleep, (3) *bedtime*: time to bed, and (4) *sleep midpoint*: halfway point between sleep onset and wake onset. Sleep diaries were kept simultaneously with actigraphy and captured self-report of the above metrics in addition to assessing sleep quality and actigraphy non-wear time. Sleep diaries were used to validate actigraphy analysis (detailed below).

Actigraphy Analysis

At least 8 complete days (ie, full 24-hour period) of sleep data were required for inclusion in actigraphy analysis. Prior research suggests that at least 8 days of actigraphy data is recommended to establish reliable sleep parameters via actigraphy.[31,32] Actigraphy data were analyzed using the ActiLife software (the ActiGraph 2012, ActiLife version 6; Pensacola, FL, USA). Analyses were based on the medium threshold setting for sleep/wake detection. Using the Cole-Kripke algorithm,[33,34] validated in adults ranging from 35 to 65 years, we identified sleep/wake in caregivers. For children, we used the Sadeh algorithm, which is validated to detect sleep/wake in subjects ranging from early childhood to young adulthood.[35] These algorithms were automatically applied to the actigraphy data using the ActiLife software. Two authors (LC and RB) visually inspected and verified the algorithm-detected sleep windows (ie, periods between "time in bed" and "time out of bed") and non-wear time using caregiver-child daily sleep

diaries. The authors completed the actigraphy analysis separately, and compared results until consensus was reached.

Statistical Analysis

Descriptive statistics were generated for all study variables. In unadjusted analysis, Pearson's correlation estimated concordance of caregiver and child sleep health metrics averaged over the 14 days. To leverage the micro-longitudinal design, linear mixed models were subsequently used to estimate the strength of within-dyad concordance between caregiver and child sleep health metrics on a daily basis across the 14 days. Specifically, multilevel models examined caregiver sleep health metrics as predictors of child sleep health, controlling for time (days), child age, and caregiver status (biological parent vs not). These covariates were chosen on a conceptual basis and the presence of statistical differences between the Delaware and Philadelphia groups. Random intercepts were used and REML estimation was employed while constructing the model (a random slope for time was considered but did not significantly improve model fit). Given that measurements between a caregiver and one of their children are likely to be related to the measurements between the same caregiver and one of their other children, caregiver ID was used to group participants as opposed to child ID. All analyses were performed using R v.3.5.2.

Results

The study sample (n= 46) was comprised of 20 caregivers and 26 children (Table 1). There were 14 dyads (one caregiver and one child) and 6 triads (one caregiver and two children). Mean caregiver age was 40.45 years (SD=11.82). Most caregivers were female (85%), and Non-Hispanic Black (80%).

Table 1: Sample Characteristics, Overall and by Study Site

Study variable	Total (N = 20 dyads/triads)	Philadelphia, PA (N = 8 dyads/triads)	Newark, DE (N = 12 dyads/triads)	P-value
Caregiver factors				
Age (years; M, SD)	40.45 (11.82)	52.38 (7.29)	32.50 (4.03)	**< 0.001**
Sex (female; N, %)	17 (85.0%)	5 (62.5%)	12 (100.0%)	0.10
Race (N, %)				0.21
Non-Hispanic Black	16 (80.0%)	8 (100.00%)	8 (66.7%)	
Non-Hispanic White	4 (20.0%)	0 (0.0%)	4 (33.3%)	
≤ High school education (N, %)	3 (15.0%)	2 (25.0%)	1 (8.3%)	0.33

Unemployed (N, %)	3 (15.0%)	2 (25.0%)	1 (8.3%)	0.70
Caregiver status (N, %)				**0.01**
Biological parent	11 (64.7%)	2 (25.0%)	9 (75.0%)	
Other	6 (30.0%)	6 (75.0%)	0 (0.0%)	
<u>**Child factors**</u>	N = 26	N = 11	N = 15	
Age (years; M, SD)	10.37 (2.65)	9.17 (2.33)	11.33 (2.55)	**0.03**
Sex (female; N, %)	12 (46.2%)	5 (41.7%)	7 (46.7%)	1.00

Mean actigraphy wear time was 8.99 days (SD=3.83) for children and 11.3 days (SD=5.51) for caregivers. Sleep duration for caregivers was 6.92 hours (SD=1.77), and 7.96 hours (SD=1.34) for children. Sleep efficiency was 76.29% (SD=9.72) for caregivers and 83.55% (SD=8.12) for children. Sleep midpoint was 2:56 AM (SD = 1.11) for children and 3:04 AM (SD = 1.11) for adults (Table 2).

Table 2: Concordance between Actigraphy-measured Caregiver and Child Sleep Duration, Bedtime, Efficiency and Midpoint (N=46)

Sleep metric	Child	Caregiver	Pearson r [95% CI]	p-value
Sleep duration (hr; M ± SD)	7.96 ± 1.34	6.92 ± 1.77	0.09 [-0.04, 0.22]	0.18
Bedtime (clock time; M ± SD)	10:47 PM ± 1.33	11:24 PM ± 1.26	0.19 [0.06, 0.32]	< 0.001
Sleep efficiency (%, M ± SD)	83.55 ± 8.12	76.29 ± 9.72	0.24 [0.12, 0.36]	< 0.001
Sleep midpoint (clock time; M ± SD)	2:56 AM ± 1.11	3:04 AM ± 1.11	0.39 [0.27, 0.49]	< 0.001

Bivariate results showed that bedtime (r=0.19, p<.001), sleep efficiency (r=0.24, p<.001), and sleep midpoint (r=0.39, p<.001) were concordant between child and caregiver (Table 2). Multivariable linear mixed models (Table 3) of child sleep showed that caregiver sleep midpoint was predictive of child bedtime, such that every hour of later sleep midpoint in caregivers was associated with 0.29 hours of later bedtime in the child (β= 0.29, p<.01). Every hour of later sleep midpoint in the caregiver was also associated with 0.31 hours later child sleep midpoint (β= 0.31, p<.001). In addition, caregiver sleep duration was predictive of child bedtime (β= 0.003, p<.05) and child sleep midpoint (β= 0.002, p<.01). Caregiver bedtime was predictive of child sleep midpoint (β= 0.16, p<.05).

Table 3: Linear Mixed Model to Show Concordance Between Child and Caregiver Sleep Health Metrics Over at 14-Day Monitoring Period (N=46)

	Independent variable			
Sleep metric	**Caregiver sleep duration** (min)	**Caregiver bedtime** (hours from midnight)	**Caregiver sleep efficiency** (%)	**Caregiver sleep midpoint** (hours from midnight)
	β ± SE	β ± SE	β ± SE	β ± SE
Child sleep duration (min)	0.02 ± 1.46	1.22 ± 0.81	0.29 ± 1.63	3.25 ± 5.63
Child bedtime (hours from midnight)	0.003 ± 0.001*	0.14 ± 0.09	-0.001 ± 0.03	0.29 ± 0.09**
Child sleep efficiency (%)	-0.01 ± 0.01	0.21 ± 0.51	-0.21 ± 0.16	-0.37 ± 0.56
Child sleep midpoint (hours from midnight)	0.002 ± 0.001**	0.16 ± 0.07*	-0.001 ± 0.02	0.31 ± 0.07***

Note: Hours from midnight is calculated as the difference between midnight and the time of interest. For example, a bedtime or sleep midpoint before midnight would have a negative value in hours, whereas bedtime or sleep midpoint after midnight would have a positive value. Models are adjusted for child age, time, and caregiver status. Fixed effects are caregiver status, time (in days), child age, and parent measure of sleep health. Random intercepts were included. *0.01 < p < 0.05; ** 0.001 < p < 0.01; ***p < .001

Discussion

On average, caregivers were not meeting national recommendations for sleep duration (7-9 hours per night) and efficiency ($\geq$85%).[36-38] Specifically, less than 50% of caregivers were obtaining at least 7 hours of sleep per night, on average. Similarly, the sleep duration recommendation of 9-11 hours per night was not met by children, with less than 30% obtaining at least 9 hours of sleep per night, on average.[36] Further, bedtime, sleep efficiency, and midpoint were significantly concordant in caregivers and

children, with the strongest association observed with sleep midpoint. Multivariable mixed linear models expounded on these bivariate results to show that caregiver bedtime predicted child sleep midpoint, and that caregiver midpoint predicted child bedtime and midpoint. These data are some of the first to objectively measure and show sleep metric concordance in caregiver-child dyads living in families experiencing socioeconomic disadvantage.

The concordance of sleep timing in caregivers and children underscores the relevance of a household rhythm in this sample of socioeconomically disadvantaged families. Indeed, consistency in sleep timing is often linked to the presence of bedtime routines,[39] which promote early bedtimes, adequate sleep duration, and efficiency in caregivers and children alike.[25,40,41] Relatedly, a time-diary study from 2454 children and adolescents showed that family-based factors, such as less time spent on family meals and fewer household rules, were associated with shorter sleep duration.[42] Meanwhile in a dyadic study with 421 older adolescents and their primary caregivers, a significant concordance between daily self-reported sleep habits was reported, even after accounting for daily experiences outside the home such as school day timing.[19] These studies converge to suggest that child sleep habits are connected to caregiver sleep health. In particular, the timing of child sleep in the 24-hour day may be a product of family level routines and culture that are largely directed by the caregiver. The current study extends this work by suggesting that this holds for socioeconomically disadvantaged families too.

Limitations, Future Directions, and Practice Implications

Findings from this pilot study are exploratory and should be interpreted cautiously in the context of the study limitations. The relatively small sample size limited the number of possible covariates in multivariable modeling. Similarly, the homogeneity of the sample limits the generalizability of our findings. Of note, the demographics of the sample align with US Census data for inner-city Philadelphia and Wilmington, Delaware populations[43]; however, the small sample size precludes our ability to draw conclusions among all families dwelling within the inner city. Moreover, the large age range of child participants (6-14 years) crossed over 2 developmental stages (school-age and adolescence) with differing sleep duration recommendations for each stage. It is suggested that 6–13-year-old children achieve 9-11 hours of sleep per night and 14-17-year-old adolescents achieve 8-10 hours of sleep per night.[36] Notably, the children in this sample did not even achieve an average of 8 hours of sleep per night.

In conjunction with our finding of short sleep duration in children, it is necessary to note that adolescents are likely to experience a delayed sleep phase.[44] Given that the older child participants in this sample were either in or approaching adolescence, it is possible that their developmental shift in sleep midpoint could have impacted our study findings.

In regard to measurement limitations, we did not measure sleep routines so we cannot address whether concordance of sleep timing is directly related to the presence of sleep routines in this sample of disadvantaged families. This is an avenue for future research as the value of bedtime routines and routine activities may vary based on level of education and cultural norms.[25] Furthermore, given the 2-week period of data collection, at least one weekend's night of sleep was obtained for caregivers and children. Likewise, data collection occurred over academic and summer months; however, examination of social jetlag and seasonality differences were beyond the scope of this study.

Strengths of this pilot study include the concurrent, objective assessment of caregiver and child sleep metrics in disadvantaged dyads over a micro-longitudinal, 14-day period. This in combination with the consideration of primary caregivers to the children in our sample, beyond just parents, is novel to this literature.

Our main finding of sleep timing concordance has implications for future research; however, it needs to be considered within the low SES family context. Indeed, adjusting sleep timing may be difficult when caregivers are working multiple jobs or unstandardized schedules. This may limit their ability go to sleep at a reasonable time or help support their child's development of healthy sleep patterns.[21,24] In such instances, it may be helpful for caregivers to rely or social or family support to help their child consistently go to bed around the same time on a nightly basis. The results of this study highlight how concordance in sleep timing may exist beyond a biological parent and may support another caregiver, positively affecting the development of healthy child sleep habits. Future research is needed to better understand the dynamic nature of sleep concordance between caregivers and children in ecologically valid contexts, especially within lower SES families, prior to the development of family-based sleep health interventions.[45]

There are several key practice implications of these findings. Primary care providers, family practitioners, and pediatric specialists alike are particularly poised to identify whether families are obtaining adequate sleep health. Despite the American Academy of Pediatrics recommendation for sleep screening at annual child well visits, few providers complete such screening.[46,47] This is an area of unmet treatment opportunity, as providers

are in an ideal position to help families understand the importance of sleep health, and can assist in identifying family-specific strategies to improve sleep health. Addressing sleep in the entire family will have a far-reaching impact on family well-being, interactions, and overall health, particularly among low SES families.[48-50]

Conclusions

Concordance of sleep timing between caregivers and children living in families experiencing socioeconomic disadvantage highlights the necessity of addressing poor sleep health at the family versus individual level. Future studies are needed to replicate these findings with larger sample sizes to better inform family-based sleep interventions and provider recommendations.

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