Changes in Bedtime Schedules and Behavioral Difficulties in 7 Year Old Children

WHAT'S KNOWN ON THIS SUBJECT: Links between clinically diagnosed sleep problems and adverse behavioral outcomes are well documented. However, in nonclinical populations, causal links between disrupted sleep and the development of behavioral difficulties are far from clear.

WHAT THIS STUDY ADDS: Seven-year-old children with nonregular bedtimes had more behavioral difficulties than children who had regular bedtimes. There were clear dose–response relationships, and the effects of not having regular bedtimes appeared to be reversible.

abstract

OBJECTIVES: Causal links between disrupted sleep and behavioral problems in nonclinical populations are far from clear. Research questions were as follows: Are bedtime schedules associated with behavioral difficulties? Do effects of bedtime schedules on behavior build up over early childhood? Are changes in bedtime schedules linked to changes in behavior?

METHODS: Data from 10 230 7-year-olds from the UK Millennium Cohort Study, with bedtime data collected at 3, 5, and 7 years, and behavioral difficulties scores as rated by mothers and teachers were analyzed.

RESULTS: Children with nonregular bedtimes had more behavioral difficulties. There was an incremental worsening in behavioral scores as exposure through early childhood to not having regular bedtimes increased: mother rated (nonregular any 1 age, $\beta = 0.53$; nonregular any 2 ages, $\beta = 1.04$; nonregular all 3 ages, $\beta = 2.10$, $P < .001$) and teacher rated ($\beta = 0.22$, $\beta = 0.73$, $\beta = 1.85$, $P < .001$). Difference in differences analysis showed that for children who changed from nonregular to regular bedtimes there were clear nontrivial, statistically significant improvements in behavioral scores: A change between age 3 and 7 corresponded to a difference of $\beta = -0.63$, and a change between age 5 and 7 corresponded to a difference of $\beta = -1.02$). For children who changed from regular to nonregular bedtimes between ages 5 and 7 there was a statistically significant worsening in scores, $\beta = 0.42$.

CONCLUSIONS: Having regular bedtimes during early childhood is an important influence on children's behavior. There are clear opportunities for interventions aimed at supporting family routines that could have important impacts on health throughout life. *Pediatrics* 2013;132:e1184–e1193

AUTHORS: Yvonne Kelly, PhD, John Kelly, BEng, and Amanda Sacker, PhD

Department of Epidemiology and Public Health, University College London, England

KEY WORDS

child behavior, sleep, Millennium Cohort Study, International Centre for Lifecourse Studies in Society and Health

ABBREVIATIONS

A/AS—advanced/advanced supplementary
CI—confidence interval
GCSE—General Certificate of Secondary Education
MCS—The Millennium Cohort Study
SDQ—Strengths and Difficulties Questionnaire

Prof Kelly conceptualized and designed the study and drafted the initial manuscript; Mr Kelly provided input on analytical strategy, carried out the initial analyses, and reviewed and revised the manuscript; Prof Sacker provided analytical support and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

www.pediatrics.org/cgi/doi/10.1542/peds.2013-1906

doi:10.1542/peds.2013-1906

Accepted for publication Aug 13, 2013

Address correspondence to Yvonne Kelly, PhD, Department of Epidemiology and Public Health, University College London, 1-19 Torrington Place, London, WC1E 6BT, UK. E-mail: y.kelly@ucl.ac.uk

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: This work was supported by a grant from the UK Economic and Social Research Council ES/J019119/1. The funders had no role in the interpretation of these data or the writing of this article.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Early child health and development have profound influences on health and well-being across the life course. Identifying putative causal factors that are amenable to change has the potential to improve population health. Children develop in complex environments with proximal influences including family routines and nurturing activities located in broader social contexts.[1,2] Sleep schedules in childhood are part of family life that are shaped by multiple biological and social influences. Lack of sleep and erratic sleep schedules have been proposed as potential stressors that have physiologic and psychological consequences.[3–6] The links between clinically diagnosed sleep problems and adverse behavioral outcomes is well documented.[7] However, in nonclinical populations, causal links between disrupted sleep and the development of behavioral difficulties are far from clear: Is it behavioral problems themselves that lead to disrupted sleep, or do sleep disruptions lead to behavioral problems? If causal links are apparent, there are clear opportunities for interventions.

Much of the previous work in this area has been cross-sectional or has not taken account of factors that might confound the association between sleep and behavioral difficulties.[8–12] Some studies have involved in-depth investigations using diary methods and actigraphy to monitor sleep,[13–15] but the generalizability of these findings from highly selective study samples is questionable. Only a couple of studies[16,17] have considered these relationships longitudinally, and a recent review article[7] highlighted the need for large-scale population-based studies to look at the links between sleep and behavior prospectively.

In this article we add to what is known by examining data from a large, nationally representative prospective population-based cohort study to see whether and how bedtimes through early childhood relate to markers of child behavior at 7 years of age. We address the following research questions:

1. Are bedtime schedules associated with behavioral difficulties?
2. Do the effects of bedtime schedules build up over early childhood?
3. Are changes in bedtime schedules linked to changes in children's behavior?

METHODS

The Millennium Cohort Study

The Millennium Cohort Study (MCS) is a nationally representative longitudinal study of infants born in the United Kingdom. The sample was drawn from births in the United Kingdom between September 2000 and January 2002. The survey design, recruitment process, and fieldwork have been described in detail elsewhere (www.cls.ioe.ac.uk/shared/get-file.ashx?id=409&itemtype=document). The first 4 sweeps of the survey involved home visits by interviewers when cohort members were aged 9 months and 3, 5, and 7 years. During structured interviews questions were asked about socioeconomic circumstances, demographic characteristics, home learning, family routines including bedtimes, and psychosocial environment. Ethical approval for the MCS was gained from the relevant ethics committees, and parents gave informed consent before interviews took place.

Bedtimes

When cohort members were aged 3, 5, and 7 years the mother was asked, "On weekdays during term-time, does your child go to bed at a regular time?" (response categories were *always, usually, sometimes,* and *never*). Questions were not asked about bedtimes on weekends. A binary variable was created to denote whether a cohort member had a regular bedtime (always or usually vs sometimes or never). Not having a regular bedtime was most common at age 3 (19.5%) compared with ages 5 and 7 (9.1% and 8.2%, respectively).

For cohort members with regular bedtimes we created bedtime categories, using responses to the question (asked at ages 5 and 7 years only), "What time is that on a weekday (during term-time)?" At age 7 these were distributed as follows: before 7:30 (10.5%), 7:30 to 7:59 (24.2%), 8:00 to 8:29 (34.1%), 8:30 to 8:59 (13.9%), and 9:00 or later (9.1%).

Behavioral Difficulties

When cohort members were aged 7, mothers and teachers were asked to complete the Strengths and Difficulties Questionnaire (SDQ), age 4 to 15 years version (www.sdqinfo.com). The SDQ is a validated tool that has been shown to compare favorably with other measures for identifying behavioral difficulties.[18,19] The SDQ asks questions about 5 domains of social and emotional behavior, namely conduct problems, hyperactivity, emotional symptoms, peer problems, and prosocial behavior. Scores from the first 4 domains are summed to construct a total difficulties score. Total difficulties scores were analyzed as continuous variables, with higher values indicating worse behavior. Mothers also completed the SDQ when their children were aged 3 and 5.

Data Analysis

Data were analyzed by using Stata version 11.2 (Stata Corp, College Station, TX). Data were weighted and analyzed by using survey methods that take account of the stratified and clustered sample design and the unequal probability of being sampled. Cross-sectional and longitudinal cumulative associations between markers of

bedtime schedules and behavioral difficulties were conducted by using linear regression models.

To assess the impact of change in the regularity of bedtimes through childhood we performed a difference in differences analysis,[20] using data on behavioral difficulties as reported by mothers at cohort member ages 3, 5, and 7 years. This method takes account of observed reductions in behavioral difficulties scores as children get older. The change in behavior score for children who experience a change in bedtime routine (treatment group) is adjusted to take account of the reduction in the group not subject to a change in bedtime routine (the control group). The underlying assumption is that the reduction in scores in the control group is an adequate proxy for the reduction that would have occurred in the treatment group without a change in bedtime routines. Thus, this method takes into account the temporal changes in behavioral scores that would be overestimated if simple differences were calculated; that is, it gives an estimate of the effect of changing bedtime regularity net of expected changes in behavioral scores.

Study Sample

We used data for singleton-born cohort members for whom information was collected on bedtimes at ages 3, 5, or 7 years, and with data on mother-reported behavioral difficulties, n = 11 544. Teacher-rated behavioral difficulties scores were available for a subsample of children, n = 7641. We excluded from our analysis cohort members who were reported to have attention-deficit/hyperactivity disorder, autism, or Asperger syndrome (n = 268). Missing data on variables included in cross-sectional and cumulative models reduced the sample size available for mother-rated difficulties to n = 10 230 (88.6%) and teacher-rated difficulties to n = 6757 (88.4%).

A slightly smaller sample of children was included in the difference in differences analyses; of those with nonregular bedtimes at age 3, 80.3% (1509/1878) changed to have regular bedtimes by age 7, and of those with nonregular bedtimes at age 5, 65.9% (617/936) had regular bedtimes by age 7; of those with regular bedtimes at age 3, 5.7% (458/7979) had nonregular bedtimes by age 7, and 5.9% (538/9158) of 5-year-olds with regular bedtimes changed to have nonregular bedtimes by age 7.

Who Participated?

Compared with families who were lost to follow-up or did not participate in all MCS sweeps, the study sample was more socially advantaged: Parents had higher incomes and educational qualifications and were more likely to be employed in professional and managerial occupations (Appendix 1).

Analytical Approach

We hypothesized that a range of factors confounded the association between bedtimes and markers of behavioral difficulties.

Model A adjusts for the age and gender of the child; model B additionally adjusts for confounders. In presented models we retained confounders that, in bivariate analysis, were statistically related both to reported bedtimes and to behavioral difficulties scores at the 10% ($P < .10$) level.

Confounders were mother's age in years; birth order (first or later born); family income (£52 000 or more, £31 200–£51 999, £20 800–£31 199, £10 400–£20 799, less than £10 400, not known); highest parental qualification (higher degree, first degree or diploma, advanced/advanced supplementary [A/AS] levels, General Certificate of Secondary Education [GCSE] grades A–C, GCSE grades D–G, other or overseas, none); mother's psychological distress (assessed by the Kessler-6 questionnaire);[21] discipline strategies score, a composite of 7 items taken from the Conflict Tactics Scale,[22] α = 0.65 (mothers were asked how often do you [never, rarely, sometimes (once per month), often (once or more per week), daily] do the following when child is "naughty": ignore, smack, shout, send to bedroom or naughty chair, take away treats, tell off, bribe); mother often irritated with child (yes or no); mother's self-rated parenting competence (better than average vs average or below average); whether breastfed (yes or no); skips breakfast (yes or no); daily activities such as help with reading (yes or no), help with math (yes or no), help with writing (yes or no); hours spent watching TV (less than 1 hour, 1 hour to under 3 hours, 3 hours or more); hours spent using computer (less than 1 hour, 1 hour to under 3 hours, 3 hours or more); parental employment (2 parent, both employed; mother only, father only, neither employed; one parent employed, not employed); whether parents felt they had enough time with child (more than

TABLE 1 Behavioral Difficulty Scores, Mean (95% confidence interval [CI]), by Weekday Bedtimes at Age 7

	Mean (CI) Total Difficulties Score	
	Mother Report	Teacher Report
Before 7:30	6.93 (6.51 to 7.34)	5.88 (5.41 to 6.34)
7:30–7:59	6.49 (6.25 to 6.74)	5.46 (5.15 to 5.76)
8:00–8:29	6.62 (6.41 to 6.84)	5.60 (5.33 to 5.87)
8:30–8:59	6.33 (6.06 to 6.60)	5.12 (4.79 to 5.45)
9:00 or later	7.42 (7.01 to 7.82)	5.75 (5.24 to 6.26)
Not regular	8.47 (8.01 to 8.92)	6.86 (6.25 to 7.46)

enough, just enough, not quite enough, nowhere near enough); child attends breakfast club; any other child care used; reading stories to child daily; having rules about time spent watching TV; overcrowding (<1 room per person); child wets bed (yes or no); child's sleep disturbed by wheezing; having a TV in bedroom (yes or no).

RESULTS

Children without regular bedtimes and those with later bedtimes (9 PM or later) had more socially disadvantaged profiles (Appendix 2). For example, they were more likely to be from the poorest homes, have parents without degree-level qualifications, and have mothers with poorer mental health. Patterns of parental employment and whether parents felt they had enough time with their children did not vary much across bedtime categories. Children with late and nonregular bedtimes were more likely to have unfavorable routines, such as skipping breakfast, not being read to daily, having a TV in their bedroom, and spending more time (>3 hours/day) watching TV compared with children with earlier bedtimes.

Are Bedtimes Related to Behavioral Difficulties?

Mean mother-rated behavioral difficulties scores were higher for children with late (after 9 PM) bedtimes than for children in the reference category (7.42 vs 6.62). Higher mean mother- and teacher-rated scores were seen for children with nonregular bedtimes (8.47 and 6.86, respectively) (Table 1). Further examination of the behavior subscales indicated that differences were not specific to any particular domain (Appendix 3). In multivariate analyses, differences in mother-rated behavioral scores for children with late bedtimes were attenuated and lost statistical significance. For children with nonregular bedtimes differences in behavioral scores were attenuated in multivariate models but retained statistical significance (mother rated, β = 0.72, and teacher rated, β = 0.75) (Table 2).

Does the Effect of Nonregular Bedtimes Build Up Throughout Early Childhood?

A clear dose–response pattern was apparent: In fully adjusted models, compared with children who always had regular bedtimes, there was an incremental worsening in scores corresponding to an increase in the number of times children did not have regular bedtimes as rated by mothers (nonregular any 1 age, β = 0.53; nonregular any 2 ages, β = 1.04; nonregular all 3 ages, β = 2.10, $P < .001$) and teachers (nonregular any 1 age, β = 0.22; nonregular any 2 ages, β = 0.73; nonregular all 3 ages, β = 1.85, $P < .001$) (Table 3).

When the Regularity of Bedtime Changes, Does Behavior Change Too?

Difference in differences analysis showed that for children who went from having nonregular bedtimes at age 3 to having regular bedtimes by age 7, there was an improvement in behavior scores (β = −0.63, P = .032). A larger effect size was detected for children who went from not having a regular bedtime at age 5 to having a regular bedtime by age 7 (β = −1.02, P = .005).

Evidence for the reverse effect was weaker as children who changed from having a regular bedtime at age 3 to not having a regular bedtime by age 7 had only slightly and statistically nonsignificant worse scores (β = 0.10, P = .684). There was a marked worsening in scores for children who changed from having a regular bedtime at age 5 to having a nonregular bedtime by age 7, and this was statistically significant (β = 0.42, P = .036) (Fig 1).

DISCUSSION

We found that 7-year-old children with nonregular bedtimes had more behavioral difficulties than children who had regular bedtimes. There was a clear dose–response pattern with incremental worsening in behavioral scores as exposure throughout early childhood to not having a regular bedtime increased. For children who

TABLE 2 Regression Coefficients (95% CI) for Behavioral Difficulties Scores by Bedtimes at Age 7, Cross-Sectional Analysis

	Mother Report			Teacher Report		
	n	Model A	Model B	*n*	Model A	Model B
Before 7:30	896	0.42 (−0.03 to 0.87)	−0.22 (−0.60 to 0.16)	587	0.52 (−0.02 to 1.05)	0.07 (−0.45 to 0.58)
7:30–7:59	2158	−0.07 (−0.37 to 0.24)	−0.10 (−0.33 to 0.13)	1470	−0.06 (−0.51 to 0.38)	−0.03 (−0.47 to 0.40)
8:00–8:29 (ref)	3506			2373		
8:30–8:59	1653	−0.29 (−0.63 to 0.05)	−0.28 (−0.58 to 0.03)	1073	−0.45 (−0.84 to −0.05)*	−0.50 (−0.88 to −0.12)*
9:00 or later	1143	0.85 (0.37 to 1.34)***	0.25 (−0.15 to 0.66)	694	0.15 (−0.41 to 0.70)	−0.19 (−0.75 to 0.37)
Not regular	874	1.99 (1.50 to 2.47)***	0.72 (0.34 to 1.10)***	560	1.39 (0.70 to 2.06)***	0.75 (0.15 to 1.35)*

Model A adjusts for child's age and gender. Model B additionally adjusts for mother's age in years, birth order, family income, highest parental qualification, mother's psychological distress, discipline strategies, mother often irritated with child, mother's parenting competence, breastfed, skips breakfast, helped with reading, helped with math, helped with writing, TV hours per weekday, computer hours per weekday, parental employment, mother's view of amount of time with child, father's view of amount of time with child, child attends breakfast club, any other child care, child read to, TV time rules, overcrowding, child wets bed, child's sleep disturbed by wheezing, TV in bedroom.

* $P < .05$.

*** $P < .001$.

TABLE 3 Regression Coefficients (95% CI) for Behavioral Difficulties Scores at Age 7, by Nonregular Bedtimes Throughout Early Childhood, Cumulative Effects

	Mother Report			Teacher Report		
	n	Model A	Model B	*n*	Model A	Model B
Always regular (ref)	7439	—	—	5003	—	—
Not regular, any 1 age	1961	1.41 (1.10 to 1.72)***	0.53 (0.26 to 0.80)***	1235	0.77 (0.36 to 1.18)***	0.22 (−0.15 to 0.59)
Not regular, any 2 ages	626	2.70 (2.12 to 3.28)***	1.04 (0.55 to 1.53)***	389	1.48 (0.79 to 2.18)***	0.73 (0.07 to 1.38)*
Not regular, all 3 ages	204	3.53 (2.56 to 4.51)***	2.10 (1.29 to 2.92)***	130	2.61 (1.29 to .94)***	1.85 (0.61 to 3.08)
P		<.001	<.001		<.001	<.001

Model A adjusts for child's age and gender. Model B additionally adjusts for mother's age in years, birth order, family income, highest parental qualification, mother's psychological distress, discipline strategies, mother often irritated with child, mother's parenting competence, breastfed, skips breakfast, helped with reading, helped with math, helped with writing, TV hours per weekday, computer hours per weekday, parental employment, mother's view of amount of time with child, father's view of amount of time with child, child attends breakfast club, any other child care, child read to, TV time rules, overcrowding, child wets bed, child's sleep disturbed by wheezing, TV in bedroom.

* $P < .05$.

*** $P < .001$.

changed from not having to having regular bedtimes, there were clear improvements in behavioral scores. There was weaker evidence for a worsening in behavior for children who changed from having to not having regular bedtimes.

Using data from a large nationally representative prospective population-based study, we assessed relationships between markers of bedtimes and multi-informant measures of behavioral difficulties while taking account of a variety of family factors. Our findings suggest causal links by virtue of satisfying certain criteria. There was a clear dose–response pattern; for example, for mother-rated difficulties there was a doubling in the magnitude of effect for each increase in exposure to nonregular bedtimes. The effect of having a nonregular bedtime appears to be reversible: For children who changed from not having to having regular bedtimes, there were improvements in behavioral scores, and for children who changed from having to not having regular bedtimes, there is some evidence for a worsening in behavior. The size of the effect was nontrivial. Meaningful clinical differences were calculated: It was estimated that a 0.9-point difference in behavioral scores would correspond to a small meaningful difference and that a 2.3-point difference would correspond to a moderate meaningful difference;[23] additionally, a 1-point difference in behavioral difficulties scores has been shown elsewhere to predict clinically diagnosed problems.[24] Thus, our results suggest that the differences detected have both clinical and statistical significance; that is, we observe approximately a 2-point difference in behavioral scores for children having nonregular bedtimes throughout early childhood and a 1-point improvement in scores for those who change from nonregular to regular bedtimes between the ages of 5 and 7.

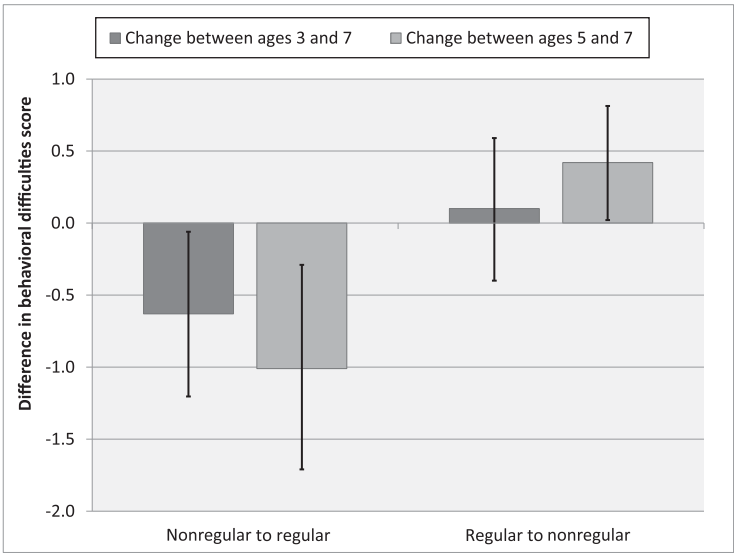

FIGURE 1
Effects of changes in the regularity of bedtimes on behavioral difficulties scores, difference in differences. Error bars represent 95% confidence intervals.

Survey attrition is a common feature of longitudinal studies. For this analysis missing data were apparent for ∼12% of the sample, and survey weights were used to take account of loss to follow-up, so our results can be generalized to the population. Another strength was the method used to assess change in the consistent nature of bedtime schedules, because the difference in differences approach reduces the likelihood of bias and residual confounding. A limitation was that direct data on sleep quantity and quality were not available. Data on bedtimes were reported by mothers and therefore could be prone to recall problems or perception bias, which may be influenced by particular experiences and

expectations. However, previous studies have shown reasonable agreement between reported bedtimes and estimated sleep time using actigraphy.[25,26]

Our findings are consistent with reports from cross-sectional studies[8–12] and a couple of longitudinal[16,17] and experimental studies[27,28] which suggested that disruptions to sleep are linked to behavioral difficulties in children. In keeping with previous studies,[26,29–31] other markers of the family milieu that we know are important predictors of early child development,[2] including mother's mental health and daily routines (eg, skipping breakfast, reading to or with child, having a TV in the bedroom, and the amount of TV watched), were all strongly correlated with not having a regular bedtime. We found that statistical adjustment for these factors attenuated associations, so our results suggest that having a regular bedtime is important alongside other aspects of family routines.

Not having a regular bedtime might affect children's behavior in two ways: via disruptions to circadian rhythms, which are slow to adapt to changes in daily schedules,[5] and via sleep deprivation and associated effects on homeostasis and brain maturation, because sleep is thought to be important in the maturation of anterior regions of the brain that are involved in the regulation of behaviors.[3,32] Inconsistent bedtimes do not necessarily equate to short sleep duration, although studies do suggest links between these parameters of sleep.[31] Given the interactive nature of circadian and homeostatic processes that govern sleep,[33,34] inconsistent schedules are likely to have knock-on effects for daytime functioning. Observed dose–response relationships suggest that there may be cumulative mechanisms at play between inconsistent bedtime schedules and behavioral outcomes. This is not surprising because behavioral adjustment is a central developmental process in early childhood, and later behavior is linked to adjustments made earlier. Therefore, inconsistent bedtime schedules in the first few years of life might set children onto particular trajectories in relation to their behavioral development, with potential knock-on effects for health and broader social outcomes throughout the life course.

CONCLUSIONS

Our analysis suggests that effects of inconsistent bedtimes are reversible, thus presenting potential opportunities for interventions. For example, screening for disruptions to bedtime schedules could be built into routine primary health care consultations. However, more research is needed to elucidate the drivers of bedtime routines because identifying such influences will help in the development of effective interventions. Furthermore, family routines can be difficult to maintain when parents are working long and potentially unsociable hours, so policy development is needed to better support families to provide conditions in which young children can flourish.

ACKNOWLEDGMENTS

We thank the MCS families for their time and cooperation, as well as the MCS team at the Institute of Education. The MCS is funded by UK Economic and Social Research Council grants to Professor Heather Joshi (study director).

This work was supported by a grant from the UK Economic and Social Research Council ES/J019119/1. The funders had no role in the interpretation of these data or in the writing of this article.

REFERENCES

1. Bronfenbrenner U, Ceci SJ. Nature–nurture reconceptualized in developmental perspective: a bioecological model. *Psychol Rev.* 1994;101(4):568–586
2. Kelly Y, Sacker A, Del Bono E, Francesconi M, Marmot M. What role for the home learning environment and parenting in reducing the socioeconomic gradient in child development? Findings from the Millennium Cohort Study. *Arch Dis Child.* 2011;96(9):832–837
3. Walker MP, Stickgold R. Sleep, memory, and plasticity. *Annu Rev Psychol.* 2006;57:139–166
4. Bryant PA, Trinder J, Curtis N. Sick and tired: does sleep have a vital role in the immune system? *Nat Rev Immunol.* 2004;4(6):457–467
5. Wittmann M, Dinich J, Merrow M, Roenneberg T. Social jetlag: misalignment of biological and social time. *Chronobiol Int.* 2006;23(1–2):497–509
6. Kelly Y, Kelly J, Sacker A. Time for bed: associations with cognitive performance in 7-year-old children: a longitudinal population-based study [published online ahead of print July 12, 2013]. *J Epidemiol Community Health.* doi:10.1136/jech-2012-202024
7. Beebe DW. Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatr Clin North Am.* 2011;58(3):649–665
8. Nixon GM, Thompson JM, Han DY, et al. Short sleep duration in middle childhood: risk factors and consequences. *Sleep.* 2008;31(1):71–78
9. Pesonen A-K, Räikkönen K, Paavonen EJ, et al. Sleep duration and regularity are associated with behavioral problems in 8-year-old children. *Int J Behav Med.* 2010;17(4):298–305
10. Arman AR, Ay P, Fis NP, et al. Association of sleep duration with socio-economic status and behavioural problems among school-children. *Acta Paediatr.* 2011;100(3):420–424
11. Carvalho Bos S, Gomes A, Clemente V, et al. Sleep and behavioral/emotional problems in children: a population-based study. *Sleep Med.* 2009;10(1):66–74
12. Biggs SN, Lushington K, van den Heuvel CJ, Martin AJ, Kennedy JD. Inconsistent sleep schedules and daytime behavioral difficulties in school-aged children. *Sleep Med.* 2011;12(8):780–786
13. Bates JE, Viken RJ, Alexander DB, Beyers J, Stockton L. Sleep and adjustment in

preschool children: sleep diary reports by mothers relate to behavior reports by teachers. *Child Dev.* 2002;73(1):62–74

14. Sadeh A, Gruber R, Raviv A. Sleep, neurobehavioral functioning, and behavior problems in school-age children. *Child Dev.* 2002;73(2):405–417
15. El-Sheikh M, Buckhalt JA, Mark Cummings E, Keller P. Sleep disruptions and emotional insecurity are pathways of risk for children. *J Child Psychol Psychiatry.* 2007;48(1):88–96
16. Gregory AM, Eley TC, O'Connor TG, Plomin R. Etiologies of associations between childhood sleep and behavioral problems in a large twin sample. *J Am Acad Child Adolesc Psychiatry.* 2004;43(6):744–751
17. El-Sheikh M, Kelly RJ, Buckhalt JA, Benjamin Hinnant J. Children's sleep and adjustment over time: the role of socioeconomic context. *Child Dev.* 2010;81(3):870–883
18. Goodman R. The Strengths and Difficulties Questionnaire: a research note. *J Child Psychol Psychiatry.* 1997;38(5):581–586
19. Goodman R. Psychometric properties of the strengths and difficulties questionnaire. *J Am Acad Child Adolesc Psychiatry.* 2001;40(11):1337–1345
20. Donald SG, Lang K. Inference with difference-in-differences and other panel data. *Rev Econ Stat.* 2007;89(2):221–233
21. Kessler RC, Andrews G, Colpe LJ, et al. Short screening scales to monitor population prevalences and trends in nonspecific psychological distress. *Psychol Med.* 2002;32(6):959–976
22. Straus M, Hamby S. Measuring physical and psychological maltreatment of children with the conflict tactics scale. In: Kaufman-Kantor G, Jasinski JE, eds. *Out of the Darkness: Contemporary Perspectives on Family Violence.* Thousand Oaks, CA: Sage; 1997
23. Crosby RD, Kolotkin RL, Williams GR. Defining clinically meaningful change in health-related quality of life. *J Clin Epidemiol.* 2003;56(5):395–407
24. Goodman A, Goodman R. Strengths and difficulties questionnaire as a dimensional measure of child mental health. *J Am Acad Child Adolesc Psychiatry.* 2009;48(4):400–403
25. Werner H, Lebourgeois MK, Geiger A, Jenni OG. Assessment of chronotype in four- to eleven-year-old children: reliability and validity of the Children's Chronotype Questionnaire (CCTQ). *Chronobiol Int.* 2009;26(5):992–1014
26. Adam EK, Snell EK, Pendry P. Sleep timing and quantity in ecological and family context: a nationally representative time-diary study. *J Fam Psychol.* 2007;21(1):4–19
27. Sadeh A, Gruber R, Raviv A. The effects of sleep restriction and extension on school-age children: what a difference an hour makes. *Child Dev.* 2003;74(2):444–455
28. Fallone G, Acebo C, Seifer R, Carskadon MA. Experimental restriction of sleep opportunity in children: effects on teacher ratings. *Sleep.* 2005;28(12):1561–1567
29. Sadeh A, Raviv A, Gruber R. Sleep patterns and sleep disruptions in school-age children. *Dev Psychol.* 2000;36(3):291–301
30. El-Sheikh M, Buckhalt JA, Mize J, Acebo C. Marital conflict and disruption of children's sleep. *Child Dev.* 2006;77(1):31–43
31. Mindell JA, Meltzer LJ, Carskadon MA, Chervin RD. Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. *Sleep Med.* 2009;10(7):771–779
32. Ringli M, Huber R. Developmental aspects of sleep slow waves: linking sleep, brain maturation and behavior. *Prog Brain Res.* 2011;193:63–82
33. Borbély AA, Achermann P. Sleep homeostasis and models of sleep regulation. *J Biol Rhythms.* 1999;14(6):557–568
34. Tononi G, Cirelli C. Sleep function and synaptic homeostasis. *Sleep Med Rev.* 2006;10(1):49–62

APPENDIX 1 Socioeconomic Characteristics of Study Sample With Mother-Reported Data on Behavioral Difficulties Compared With Those Lost to Follow-Up

	Lost to Follow-Up (n = 6831)	Excluded or Missing Covariates (n = 1491)	Analyzed Sample (n = 10 230)
Family type			
2 parent	78.6	86.3	90.3
1 parent	21.4	13.7	9.7
Family income			
£52 000 or more	4.6	5.6	7.9
£31 200–£51 999	10.2	12.8	19.8
£20 800–£31 199	15.7	17.7	23.7
£10 400–£20 799	30.1	30.4	28.6
Less than £10 400	30.0	23.9	14.1
Not known	9.3	9.6	5.9
Highest parental qualification			
Higher degree	5.6	7.1	8.2
First degree or diploma	26.9	31.9	42.9
A/AS levels	16.1	14.8	16.3
GCSE grades A–C	28.0	20.7	23.4
GCSE grades D–G	7.5	6.9	4.2
Other or overseas	2.3	3.9	0.9
None	13.6	14.8	4.1
Highest parental occupational class			
Managerial or professional	16.0	18.8	26.3
Intermediate	11.5	10.4	13.6
Small employer or self-employed	6.9	8.2	9.8
Low supervisory or technical	9.3	9.8	10.2
Semiroutine or routine	48.8	45.9	37.6
Refused or missing	7.5	6.8	2.5

APPENDIX 2 Distribution of Socioeconomic and Family Factors by Usual Weekday Bedtimes at Age 7

	Usual Weekday Bedtime at Age 7					
	Before 7:30	7:30–7:59	8:00–8:29	8:30–8:59	9:00 or Later	Nonregular
Child age, y, mean	7.2	7.2	7.2	7.3	7.2	7.2
Gender, male	45.3	49.8	51.9	49.7	52.2	50.2
Mother's age, y, mean	34.5	35.9	36.4	36.7	36.0	36.2
Birth order, firstborn	50.3	49.9	42.0	33.3	34.0	39.6
Family income						
£52 000 or more	10.1	17.3	15.0	13.6	7.3	7.3
£31 200–£51 999	21.2	26.2	27.3	25.6	19.0	17.1
£20 800–£31 199	22.8	21.6	20.9	21.7	20.4	21.3
£10 400–£20 799	25.7	19.5	19.8	20.6	30.6	24.3
Less than £10 400	11.0	7.7	8.9	10.5	12.6	17.6
Not known	9.2	7.8	8.0	8.0	10.0	12.4
Highest parental qualification						
Higher degree	10.9	14.3	12.9	14.1	9.0	8.2
First degree or diploma	35.1	41.5	41.9	35.3	25.8	29.3
A/AS levels	17.2	16.0	15.4	16.0	19.0	16.4
GCSE grades A–C	23.5	20.6	21.2	24.4	26.5	27.4
GCSE grades D–G	7.0	3.6	4.0	4.1	7.1	6.2
Other or overseas	1.2	0.6	1.1	1.3	3.8	3.0
None	5.1	3.5	3.5	4.8	8.8	9.5
Mother's psychological distress, mean	3.1	2.9	2.8	2.9	3.1	4.0
Discipline strategies score, mean	1.7	1.6	1.5	1.4	1.5	1.5
Mother often irritated with child	19.7	19.3	18.4	14.7	16.9	24.4
Mother's parenting competence, better than average	57.0	63.5	63.7	63.5	66.9	55.3
Breastfed, ever	66.2	74.7	71.1	65.9	60.1	60.3
Skips breakfast, ever	2.8	2.2	4.2	6.1	11.6	13.5
Helped with reading, daily	22.9	26.3	22.4	20.0	23.5	18.2
Helped with math, daily	6.8	6.5	5.6	5.6	7.3	6.5
Helped with writing, daily	11.1	11.2	9.8	10.3	12.5	10.4
TV hours per weekday						
Less than 1 h	22.7	23.5	20.7	15.6	14.6	16.7
1 h to under 3 h	62.4	65.7	65.4	67.3	65.8	60.1
3 h or more	14.9	10.8	13.9	17.0	19.5	23.3
Computer hours per weekday						
Less than 1 h	69.6	68.8	66.5	62.4	56.0	56.2
1 h to under 3 h	26.9	28.5	30.1	33.2	37.3	38.4
3 h or more	3.5	2.7	3.4	4.4	6.7	5.4
Parental employment						
2-parent household						
Both employed	47.4	57.3	56.2	56.1	45.6	47.1
Mother only	1.2	1.9	1.7	1.5	2.7	2.2
Father only	22.6	21.4	20.5	18.0	21.5	20.4
Neither	6.8	3.7	2.7	3.2	6.2	4.7
1-parent household						
Employed	9.9	8.9	10.8	11.6	11.7	12.7
Not employed	12.0	6.8	8.2	9.6	12.4	13.1
Mother's view of amount of time with child, not enough	31.4	32.2	33.4	32.6	27.8	32.3
Father's view of amount of time with child, not enough	59.2	62.2	57.6	58.3	45.8	49.2
Child attends breakfast club	10.2	9.9	11.4	12.7	11.7	10.0
Any other child care	32.1	28.8	31.6	36.7	36.3	40.1
Child read to, daily	49.9	55.4	49.4	42.4	33.8	36.1
TV time rules	89.7	86.4	86.2	82.7	75.2	67.6
Overcrowding	9.2	4.7	6.4	8.2	14.7	13.0
Child wets bed	13.8	14.0	15.0	14.4	11.4	14.1
Child's sleep disturbed by wheezing	7.2	6.8	7.2	6.6	7.5	9.5
TV in bedroom	55.0	44.6	49.3	57.6	63.8	64.2

APPENDIX 3 Behavioral Difficulties Subscale Scores, Mean (95% CI), by Weekday Bedtimes at Age 7

	Mean Score (CI)	
	Mother Report	Teacher Report
Conduct problems		
Before 7:30	1.33 (1.23 to 1.43)	0.71 (0.58 to 0.84)
7:30–7:59	1.23 (1.16 to 1.31)	0.70 (0.61 to 0.79)
8:00–8:29	1.30 (1.23 to 1.36)	0.66 (0.60 to 0.73)
8:30–8:59	1.27 (1.19 to 1.34)	0.60 (0.52 to 0.69)
9:00 or later	1.43 (1.31 to 1.56)	0.77 (0.62 to 0.91)
Not regular	1.79 (1.66 to 1.93)	0.92 (0.76 to 1.09)
Hyperactivity		
Before 7:30	3.27 (3.09 to 3.45)	2.87 (2.63 to 3.11)
7:30–7:59	3.12 (3.00 to 3.25)	2.62 (2.45 to 2.78)
8:00–8:29	3.22 (3.11 to 3.32)	2.65 (2.51 to 2.79)
8:30–8:59	3.06 (2.93 to 3.20)	2.51 (2.33 to 2.70)
9:00 or later	3.47 (3.30 to 3.65)	2.86 (2.60 to 3.12)
Not regular	3.81 (3.62 to 3.99)	3.27 (2.97 to 3.57)
Emotional symptoms		
Before 7:30	1.53 (1.40 to 1.65)	1.45 (1.27 to 1.62)
7:30–7:59	1.42 (1.34 to 1.50)	1.35 (1.24 to 1.46)
8:00–8:29	1.38 (1.32 to 1.45)	1.44 (1.35 to 1.53)
8:30–8:59	1.35 (1.25 to 1.46)	1.27 (1.14 to 1.40)
9:00 or later	1.64 (1.49 to 1.78)	1.30 (1.12 to 1.47)
Not regular	1.83 (1.68 to 1.97)	1.68 (1.48 to 1.87)
Peer problems		
Before 7:30	1.18 (1.06 to 1.30)	1.21 (1.06 to 1.36)
7:30–7:59	1.10 (1.02 to 1.17)	1.05 (0.96 to 1.13)
8:00–8:29	1.06 (1.00 to 1.12)	1.05 (0.97 to 1.13)
8:30–8:59	0.96 (0.88 to 1.04)	0.93 (0.83 to 1.02)
9:00 or later	1.29 (1.16 to 1.41)	1.05 (0.91 to 1.19)
Not regular	1.57 (1.43 to 1.70)	1.32 (1.14 to 1.50)

Changes in Bedtime Schedules and Behavioral Difficulties in 7 Year Old Children

Yvonne Kelly, John Kelly and Amanda Sacker

Pediatrics originally published online October 14, 2013;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Changes in Bedtime Schedules and Behavioral Difficulties in 7 Year Old Children

Yvonne Kelly, John Kelly and Amanda Sacker

Pediatrics originally published online October 14, 2013;