

Sleep and Delinquency: Does the Amount of Sleep Matter?

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Abstract Sleep, a key indicator of health, has been linked to a variety of indicators of well-being such that people who get an adequate amount generally experience greater well-being. Further, a lack of sleep has been linked to a wide range of negative developmental outcomes, yet sleep has been largely overlooked among researchers interested in adolescent delinquency. The purpose of this study was to explore the relationship between hours of sleep and delinquent behavior among adolescents by using data from Wave 1 of the National Longitudinal Study of Adolescent Health ($n = 14,382$; 50.2% female, 63.5% white). A series of negative binomial regressions showed that youth who typically sleep seven or fewer hours per night reported significantly more property delinquency than youth who sleep the recommended 8–10 h. Further, youth who reported sleeping 5 or fewer hours per night reported significantly more violent delinquency than youth who reported sleeping the recommended number of hours per night. The findings suggest that sleep is an important, and overlooked, dimension of delinquent behavior and studies that focus on adolescent health should further investigate the effects of insufficient sleep. Finally, the authors

recommend that sleep and other relevant health behaviors be considered in the context of more comprehensive approaches to delinquency prevention and intervention.

Keywords Sleep · Delinquency · Developmental criminology · Health

Introduction

In recent years, there has been growing emphasis on criminological theories that employ a developmental perspective within the study of crime. Specifically, developmental criminology examines various social and biological factors that influence the onset, maintenance, and desistance of offending behavior. Unlike static criminological theories, developmental criminology contextualizes offending within a broader set of lifestyle factors that influence human development (i.e., progression from childhood to adolescence to adulthood). Criminologists have examined a variety of developmental factors related to adolescent delinquency (Wade and Pevalin 2005), such as neurological deficiencies (Moffitt et al. 1994), pregnancy complications (Farrington 1997), sexual behavior (Armour and Haynie 2007), and pubertal development (Felson and Haynie 2002; Haynie 2003). Although criminologists are beginning to focus on developmental factors, a number of health-related areas remain unexplored.

Clearly, one of the most important dimensions of human development is physical health, or the overall wellbeing of the body that is typically achieved through proper diet, exercise, and adequate health care (NACRO 2008). Adolescents who participate in health-promoting activities experience social, psychological, and emotional advantages. Exercise, for example, has been linked to self-esteem

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(Faulkner et al. 2007), academic performance (Smith and Lounsbury 2009), and emotional efficacy (Valois et al. 2008). Although healthy practices have been linked to positive outcomes, research on juvenile delinquency rarely considers the effects of physical health.

A number of studies have examined physical health problems as an outcome of a delinquent lifestyle (Farrington 1995a; Piquero et al. 2007; Shepherd and Farrington 2003). For example, much of the research in the area of health and delinquency has focused on delinquent behavior and contact with the juvenile justice system as a precursor to poor health. In fact, research has found that, when compared to non-delinquents, delinquent adolescents have more medical contacts, including treatments for illness, injury, accidents, and chronic conditions (Farrington 1995a). Delinquent youth also present lower perceived health status (Junger et al. 2001) and greater risk of premature death (Shepherd and Farrington 2003). While health is typically treated as an outcome measure, it may also have a predictive relationship with offending behavior. Although researchers are beginning to examine the relationship between developmental factors and delinquency, the effects of insufficient sleep on delinquency is one area that remains relatively neglected.

From a developmental perspective, insufficient sleep during adolescence is likely to have serious consequences in terms of risk-taking behavior, including delinquency. A lack of sleep is especially problematic as research continues to demonstrate that sufficient sleep is necessary for achieving optimal health and that insufficient sleep results in a variety of negative consequences (Vail-Smith et al. 2009). As a result, our study explores whether youth who sleep the recommended number of hours per night participate in less delinquency than youth who do not sleep a sufficient number of hours per night.

Sleep Deprivation, Physical Health, and Adolescent Development

While health is affected by a complex interplay of factors, obtaining an appropriate amount of sleep is a necessary condition for high quality physical health. In the United States, insufficient sleep has recently been identified as a serious public health problem (Colten and Altevogt 2006). Insufficient sleep not only adversely affects stress management skills but also increases the risk of colds and infections, is implicated as an important contributor in occupational and traffic accidents, and is linked to chronic disease (National Center for Chronic Disease Prevention and Health Promotion 2008; National Highway Traffic Safety Administration 2008; National Sleep Foundation 2006). In general, sleep length has been associated with subjective and psychological well-being, as well as overall

life satisfaction (Hamilton et al. 2007; Kelly 2004). Also, various studies find that insufficient sleep is related to heightened levels of negative emotion states such as depression, anger, sadness, and fear (Morrison et al. 1992; Wolfson and Carskadon 1998). Similarly, research suggests a positive relationship between insufficient sleep and suicidal symptoms, even after controlling for depressive symptoms (Roane and Taylor 2008; Roberts et al. 2001; Sjöström et al. 2007). Such negative effects of sleep deprivation are felt across the range of human development, from infants and young children, to the elderly.

Sleep deprivation further impacts the lives of individuals through a number of neurocognitive consequences. Neurobehavioral models suggest that sleep loss results in temporary changes in cerebral metabolism, cognition, emotion, and behavior consistent with mild prefrontal lobe dysfunction (Killgore et al. 2008). Previous research demonstrates that even a single night of sleep deprivation can result in decreased performance on various executive functioning tasks (Hsieh et al. 2007; Nilsson et al. 2005). Executive functioning refers to a range of higher-order cognitive activities that involve the initiation, planning, and self-regulation of goal-directed behavior (Berger and Posner 2000). The specific cognitive skills generally considered part of executive functioning include attention control, hypothesis generation, strategic planning, abstract reasoning, process information in working memory, and cognitive flexibility; all of which are important in everyday decision-making (Syngelaki et al. 2009).

While the importance of sufficient sleep has been clearly demonstrated, studies consistently show that a large number of individuals are sleep deprived (Allen 1992; O'Brien and Mindell 2005). Although adolescents generally sleep less than younger children, research suggests that sleep is even more critical for adolescents as their bodies and brains are experiencing rapid growth and development (Carskadon 1990, 2002; Dahl and Lewin 2002). Adolescent sleep deprivation often results in various mental and somatic health issues (Roberts et al. 2009). For example, a lack of sleep among adolescents is associated with increased risk for depression, school problems, and motor-vehicle accidents (Carskadon et al. 2004; Fredriksen et al. 2004). Further, the executive functioning effects of sleep deprivation may be especially detrimental during adolescence due to the already vulnerable period of brain development (Dahl 2004) in which sensation-seeking is enhanced, and decision-making is impaired (Kelley et al. 2004; Steinberg 2004).

Delinquency and Sleep in the Adolescent Context

The evidence above suggests that a lack of sleep has a variety of negative effects on adolescent development, yet

few studies have examined its effect on delinquency. This relationship seems especially important and obvious given that youth are sleeping fewer hours than they should, but also because adolescents are disproportionately engaged in crime. Research on the relationship between age and crime suggests that involvement in violent crime and property crime rises during childhood, peaks in adolescence, and then declines in adulthood (Farrington 1986; Greenberg 2008). Although many offenders commit both property and violent offenses, property offenses are much more prevalent (Puzzanchera 2009; Swatt et al. 2008). In 2008, 15.4% of violent crime arrests and 26% of property crime arrests were youth under the age of eighteen (US Department of Justice 2008). The disproportionate involvement of youth in offending is even more pronounced in victimization data, where 20.1% of violent single-offenders were perceived to have been between the ages of 12 and 17, and 39.7% of multiple-offender violent victimizations were reported to have been committed by youth between the ages of twelve and twenty (US Department of Justice 2007). At the same time that this disproportionate involvement is happening, research suggests that many youth are receiving less sleep than they should; creating a relationship that deserves further exploration.

Although previous studies have begun to examine the relationship between physical health and offending behavior over the life course, there is relatively little research addressing the effects of sleep in relationship to juvenile delinquency. The little research that does exist focuses primarily on institutionalized adults suffering from severe psychiatric disorders (Lindberg et al. 2003, 2004) or incarcerated male adolescents (Ireland and Culpin 2006). As such, these studies do not explore sleep length as it relates to delinquent activity in the general adolescent population, rather they explore sleep disturbance and psychiatric disorders or negative emotions (i.e., aggression) within institutionalized offender populations. Additionally, these studies do not look specifically at delinquent behavior, but focus instead on measures of underlying hostility and aggression (Ireland and Culpin 2006; Lindberg et al. 2003, 2009). We are interested in sleep and delinquent behavior among non-institutionalized adolescents.

In our review, we found two relevant studies that focused on non-institutionalized adolescents. First, O'Brien and Mindell (2005) used data from 388 high school students in Philadelphia to examine the relationship between sleep problems (i.e., total sleep time, weekend delay and oversleep, daytime sleepiness, and sleep-wake problems) and several measures of risk-taking, which included measures of adolescent violence. They found a significant relationship between sleep-wake problems (e.g., being late to class because of oversleeping, staying up late, trouble falling asleep, etc.) and risky behaviors. With regard to

amount of sleep, the authors found that low-end sleepers (≤ 6 h 45 min) participated in significantly more risky alcohol and sexual behaviors than high-end sleepers (≥ 8 h 15 min). Total sleep time, however, was not related to violence, safety behaviors, or drug-use. The second study examined how "possible sleep insomnia" was related to five measures of risky behavior (Cattrett and Gaultney 2009). Cattrett and Gaultney (2009) found that possible insomnia (i.e., troubled sleep and tiredness) significantly predicted smoking, delinquency, and drinking and driving. The authors also found a relationship between sleep-relevant variables and risky behavior, though they did not specifically examine amount of sleep. While these two studies provide preliminary evidence of a relationship between sleep habits and risky behavior, further study is warranted, specifically with regard to the amount of sleep an adolescent receives.

In order to build on previous research, it is important to consider the relationship between sleep and delinquency, not in isolation, but in the context of other developmentally important constructs. Although a review of all factors related to sleep or delinquency is beyond the scope of this paper, we briefly discuss a few constructs that are most pertinent: depressive symptoms, impulsivity, parental supervision, and parental permissiveness. Each of these constructs is noteworthy in the consideration of adolescent development, in general, as well as in its specific relationship to sleep and delinquency.

Depression can significantly impair adolescent functioning, and it has been linked to both sleep and delinquency. It is estimated that approximately 5% of adolescents meet the clinical criteria for depression and even more experience depressive symptoms (Brent and Birmaher 2002). A number of studies have found a link between sleep disturbance and depressive symptoms (see Roberts et al. 2001 for review) with one study, in particular, indicating that approximately 89% of clinically depressed adolescents suffer some form of sleep disturbance (Lewinsohn et al. 1998). Another study found that middle school youth who reported fewer hours of sleep also reported more depressive symptoms in both cross-sectional and longitudinal data (Fredriksen et al. 2004). Although there is more evidence on the relationship between depression and sleep, depressive symptoms have also been linked to delinquency (Beyers and Loeber 2003; Loeber et al. 1998) and thus deserve consideration in any exploration of sleep as it relates to delinquency.

Adolescent impulsivity has also been linked to a range of risky or problem behaviors (see Sher and Trull 1994, for review). Impulsivity has been defined as "actions that are poorly conceived, prematurely expressed, unduly risky, or inappropriate to the situation and that often result in undesirable outcomes" (Evenden 1999, p. 348). Impulsivity has

been linked to delinquency, including early onset delinquency in a number of studies (Carroll et al. 2006; Farrington 1995b; Shepherd and Farrington 2003) and there is some evidence that this relationship is invariant across different levels of neighborhood ecology (Vazsonyi et al. 2006). Findings on this relationship are mixed, however, as not all research finds a significant link between impulsivity and delinquency (see for example, Osgood and Anderson 2004). In addition, a few studies have found a relationship between various sleep problems and impulsivity (Ireland and Culpin 2006; Schmidt et al. 2008), though more research is warranted.

Parenting practices represent another aspect of the adolescent context within which, the relationship between sleep and delinquency must be considered. A considerable amount of research has examined the relationship between parental supervision, parental permissiveness, and delinquency (Glueck and Glueck 1950, 1968; Rankin and Wells 1990; Sampson and Laub 1993; Simons et al. 2004). Parental supervision involves monitoring adolescent behavior directly or indirectly, such as knowing where the adolescent is or knowing how to reach them. Sampson and Laub (1993) found that mothers' supervision had the largest effect on delinquency after controlling for a number of important child and family factors. Other research has linked a lack of parental supervision to a variety of delinquent activities (Gottfredson et al. 2001; Richardson et al. 1993). Similarly, a number of studies have found a relationship between permissive parenting and developmental outcomes (see Baumrind 1971; Lamborn et al. 1991; Simons et al. 2004). Steinberg et al. (1994) reported that youth who were raised in indulgent homes showed significant increases in school misconduct as well as significant declines in school orientation over time. Permissive parenting generally involves a lack of parental control, including rule-setting and enforcement, and overlooking disobedience, all of which could lead to delinquency.

Purpose and Hypotheses

Despite the need for adequate sleep throughout adolescence, there is evidence to suggest that the amount of sleep youth obtain actually decreases throughout adolescence and results in corresponding sleep deprivation (Carskadon 1990; Roberts et al. 2009). Further, there is ample evidence to suggest that adolescents who do not sleep an adequate amount are more likely to experience negative outcomes, including deficits in cognitive functioning (Ortega et al. 2010), poor academic performance (Meijer 2008), and diminished social competence (Dahl and Lewin 2002). In response to the growing evidence regarding the importance of sleep for adolescent development, a number of national

organizations have begun to publicize general sleep recommendations for people, and adolescents, in particular. Current recommendations for adolescents fall between 8.5 and 9.25 h (National Sleep Foundation 2010). Although the importance of sleep in adolescence has been established, there is still a need for further research on the specific consequences associated with not getting the recommended amount of sleep.

The purpose of the current study is to investigate whether the number of hours an adolescent sleeps per night is related to delinquent behavior. We expect that the relationship between the amount of sleep and delinquency will follow a pattern similar to other developmental outcomes (i.e., less sleep associated with less favorable outcomes). Specifically, we hypothesize that youth who sleep fewer hours than recommended will commit more property and violent delinquency than those who report meeting sleep requirements. Although these specific relationships have yet to be tested, inadequate sleep has been preliminarily linked to risky alcohol-use and sexual behaviors (O'Brien and Mindell 2005). Thus, we expected inadequate sleep to be similarly linked to self-reported delinquent behavior. Second, we expect an inverse relationship between hours of sleep and property and violent delinquency such that the youth who are most sleep-deprived (i.e., report sleeping the fewest number of hours) will be at the highest risk for delinquency. Again, this has yet to be tested in the case of delinquency, although previous research does provide evidence that greater sleep deprivation is related to greater psychosocial functioning impairment (see for example, Roberts et al. 2009). Finally, there is evidence that property delinquency is much more common than violent delinquency (Puzzanchera 2009) and that different types of problem behavior may be associated with varying levels of risk (see for example, Appleyard et al. 2005). As such, we test both of our hypotheses separately for property and violent delinquency.

The current study builds on previous explorations of sleep and risk by controlling for relevant developmental characteristics and contexts. Depressive symptoms and impulsivity are characteristics that have been linked both to delinquency and sleeping problems and thus will be controlled for in our analysis. Further, parenting practices can influence participation in delinquent behavior, and preliminary research suggests that they also may be related directly to sleep hygiene. Though we cannot control for all aspects of the parent–child relationship, we do control for supervision and permissiveness in our analysis. Finally, any investigation of sleep and delinquency should rule out the possibility that youth are not sleeping simply because they are out late at night participating in delinquent behavior (i.e., delinquent behavior is the reason for not sleeping). We expect the effect of night-time activities to

be minimal because past research indicates that the majority of juvenile arrests occur in the time before and after school (Snyder and Sickmund 1999). We do not expect the relationship between hours of sleep and delinquency to be diminished once we control for these related characteristics.

Method

Data and Sample

We draw on data from Wave 1 of the National Longitudinal Study of Adolescent Health (Add Health), a study conducted by the North Carolina Population Center at the University of North Carolina. The data from Wave 1 include a prospective nationally representative sample of adolescents who were in grades 7 through 12 between September 1994 and December 1995 (Udry 2003). Using unequal stratified sampling techniques; a total of 80 high schools and 52 middle schools in the United States were selected for the study. The study was designed to ensure that the sample was representative of schools with respect to region of the country, urbanicity, school size, school type, and ethnicity (Harris et al. 2003). The overall study consisted of data collected from a number of sources, including: an in-school student questionnaire, a school administrator questionnaire, an in-home student interview, and a parent questionnaire.

Roughly 90,000 students completed the Wave 1 in-school questionnaire, which asked students about their demographic characteristics, various behaviors, home-life, and social relationships. More in-depth information was subsequently obtained from the in-home interview component of the survey, which was conducted with a randomly selected subsample of students identified through school rosters. During the in-home survey component, interviewers used laptop computers to gather data from adolescents ($n = 20,745$) and their respective primary caregivers ($n = 17,700$; Harris et al. 2003). The in-home instrument asked questions about the adolescent's delinquent behaviors, sexual relationships, relationships with family members, and various other topics. Answers to sensitive topics during the in-home component were recorded via an audio computer assisted self-interview (CASI) system.

The current study uses data obtained from the adolescent in-home survey; however, our measure of poverty was derived from in-home parent survey questions. A number of respondents had missing data on the weight variable ($n = 2,336$) or on one of the three items used to measure poverty ($n = 2,914$), and, as a result, these cases were removed from our final sample. After removing these

cases, and additional cases with missing data on one or more of the variables, our final sample consisted of 14,382 adolescents. Throughout our analysis, we used appropriate sample weights to ensure that our final sample was a national representation of American adolescents (see Chantala and Tabor 1999). The final sample was 50.2% female and ranged in age from 13 to 19 ($M = 15.68$, $SD = 1.60$). The sample was primarily white (63.5%) and non-Hispanic (83.5%) with 14% of youth living in poverty.

Measures

Property Delinquency

Property offending was measured as a scale of summed responses to items asking participants the number of times they engaged in a particular delinquent behavior over the past 12 months (Anderson and Hughes 2009). Corresponding response categories for each question included never (0), 1 or 2 times (1), 3 or 4 times (2), or 5 or more times (3). Higher scores represent not only more types of behaviors but also a greater frequency of those behaviors. For property offending, five items were used to create the scale: “deliberately damage property that didn't belong to you”; “take something from a store without paying for it”; “steal something worth more than \$50”; “go into a house or building to steal something”; and “steal something worth less than \$50” ($\alpha = .77$). Approximately 64% of respondents reported that they had not participated in a property offense.

Violent Delinquency

Violent offending was measured as a scale of summed responses to items asking participants the number of times they engaged in a particular delinquent behavior over the past 12 months (Anderson and Hughes 2009). Corresponding response categories for each question included never (0), 1 or 2 times (1), 3 or 4 times (2), or 5 or more times (3). Higher scores represent not only more types of behaviors but also a greater frequency of those behaviors. Four items were used to create the violent offending scale: “get into a physical fight”; “hurt someone badly enough to need bandages or care from a doctor or nurse”; “take part in a fight where a group of your friends was against another group”; and “use or threaten someone with a weapon” ($\alpha = .73$). Approximately 59% of respondents indicated they had never participated in a violent offense. The high percentage of youth who have not participated in delinquency as well as the positive, whole number count structure of the measures necessitate the use of certain types of data analysis, which will be discussed later.

Hours of Sleep

Our variable of interest was based on a single item that asked respondents, “How many hours of sleep do you usually get a night?” This question was measured as a continuous variable ranging from 0 to 20 h per night and subsequently recoded to create a sleep hours dummy variable. The reference category, which consists of those youth who report receiving 8–10 h of sleep (42%), captures the recommended range of sleep for adolescents (National Sleep Foundation 2010). The other sleep categories were based on the recommended range minus one or more hours: 7 h (24%), 6 h (12%), or 5 or fewer hours (4%).

Depressive Symptoms

We measured depressive symptoms using 18 items from the CES-D scale (Radloff 1977). Items were reverse coded as necessary and summed to create a depressive symptoms measure ($\alpha = .91$). Participants were asked how often they had experienced various conditions in the last week (e.g., “You felt depressed”; “You felt lonely”; “You felt hopeful about the future”). Items were measured on a four-point scale ranging from “rarely” to “most/all of the time” with higher scores indicating more depressive symptoms. Scale scores ranged from 0 to 40 ($M = 10.11$, $SD = 6.78$).

Impulsivity

Four items, specifically related to decision-making, were used to measure impulsivity: “When you have a problem to solve, one of the first things you do is get as many facts about the problem as possible”; “When you are attempting to find a solution to a problem, you usually try to think of as many different ways to approach the problem as possible”; “When making decisions, you generally use a systematic method for judging and comparing alternatives”; and “After carrying out a solution to a problem, you usually try to analyze what went right and what went wrong” (Vazsonyi et al. 2006). Items were measured on a 5-point scale ranging from strongly agree to strongly disagree, with higher scores indicative of greater impulsivity ($\alpha = .74$). Scores on this measure ranged from 4 to 20 ($M = 8.75$, $SD = 2.50$).

Parental Permissiveness

A seven-item parental permissiveness scale (Wright et al. 2008) was created to tap into decisions that parents make for their child (the respondent). The index includes decisions about (1) the time you must be home on weekend nights; (2) the people you hang out with; (3) what you wear; (4) how much television you watch; (5) which

television programs you watch; (6) what time you go to bed on week nights; and (7) what you eat. A point is given for each item about which the child makes the decision. Scores range from 0 to 7 ($M = 5.19$, $SD = 1.54$), where higher scores represent greater permissiveness.

Parental Supervision

In addition, parental supervision was measured using a three-item index that gauges how often (1) the parent is at home when you leave for school; (2) the parent is at home when you return from school; and (3) the parent is at home when you go to bed. These three items were asked of both the mother and father. Since not all adolescents live with two residential parents, we use the higher score for either the mother or the father to construct this index (Demuth and Brown 2004). Original items were reverse coded as (0) never; (1) almost never; (2) some of the time; (3) most of the time and (4) always. As a result, corresponding scores for the index range from 0 to 12 ($M = 9.43$, $SD = 2.23$), with higher scores indicating greater parental supervision.

Late Night Activities

Measures of late-night or nocturnal activities were limited in the Add Health data and so we included the best proxy measure available. The item asked, “During the past 12 months, have you ever spent the night away from home without permission?” (0 = No, 1 = Yes). Approximately 13% of youth answered that they had spent a night away from home without permission.

Demographics

Several dummy variables were created to capture sex (0 = Female, 1 = Male), ethnicity (0 = non-Hispanic, 1 = Hispanic), and race (0 = non-White, 1 = White). Respondent’s age was measured as a continuous variable and ranged from 11 to 21 years of age; however, we restricted our analysis to those adolescents between 13 and 19 years of age, which was mean-centered at 16 years of age. An age-squared term was also included to allow for either increasing or diminishing effects of each additional year (Long and Freese 2006). Lastly, primary caregivers who reported receiving Aid to Families with Dependent Children, food stamps, or a housing subsidy were coded as an affirmative on the poverty variable (0 = No Poverty, 1 = Poverty).

Analysis Plan

The complex nature of the Add Health design requires the implementation of survey correction procedures in order to

produce unbiased estimates of variance and standard errors (Chantala and Tabor 1999). Data analyses were conducted using STATA (v. 11), a software package that includes procedures for correctly analyzing complex survey designs. A series of survey-weighted negative binomial regressions were conducted to explore the relationship between sleep and delinquency (property and violence) while controlling for a variety of other factors. Negative binomial regression is used with positively skewed count data and is preferred over the Poisson model due to the overdispersed (i.e., variance greater than the mean) nature of the data (Gardner et al. 1995; Long and Freese 2006). Negative binomial models also allow for easy interpretation as the exponentiated (e^b) coefficient can be understood in terms of percent decreases in the outcome variable [$\% = 1 - (\exp(\text{coef}))$] for negative values or increases in the outcome variable ($\exp(\text{coef}) - 1$) for positive values.

Results

The answer to our first hypothesis can be found in Table 1. The bivariate correlations suggest a positive relationship between not obtaining the recommended amount of sleep and property and violent delinquency. Sleeping 7 or fewer hours was significantly related to property delinquency while 6 or fewer hours was related to violent delinquency. The main two correlates of delinquency, gender and age, show their typical relationships with males committing more delinquency than females and that adolescents younger than 16 years of age are more likely to commit delinquent acts. Importantly, all of the correlations are within the acceptable bounds to proceed with further analysis.

As noted earlier, we expected to find that youth who sleep fewer hours than recommended participate in more delinquency (both property and violent). Further, we expected that each hour of sleep an adolescent did not receive would result in increased delinquency. We present the regression results across four models in Table 2. Model 1 shows the relationship between hours of sleep and property delinquency while controlling for basic demographic factors. Model 2 includes the addition of theoretically relevant control variables: depressive symptoms, impulsivity, parental supervision and permissiveness, and late-night activities. Models 3 and 4 are identical to 1 and 2 except they focus on violent rather than property delinquency.

Property Delinquency

Model 1 in Table 2 provides support for our hypothesis as the results show that, compared to the reference group of

Table 1 Bivariate correlations

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Property														
2. Violent	0.43**													
3. Gender	0.13**	0.20**												
4. Age	-0.03**	-0.05**	0.04**											
5. Ethnicity	0.04**	0.07**	0.00	0.07**										
6. White	0.00	-0.10**	0.01	-0.03**	-0.16**									
7. Poverty	0.00	0.10**	-0.03**	-0.03**	0.09**	-0.17**								
8. ≤5 h	0.05**	0.06**	-0.03**	0.10**	0.01	-0.06**	0.02*							
9. 6 h	0.05**	0.04**	-0.03**	0.14**	0.00	-0.06**	0.02*	-0.08**						
10. 7 h	0.00	-0.02**	0.06	0.11**	0.01	-0.02*	-0.03**	-0.12**	-0.21**					
11. Impulsivity	0.13**	0.08**	-0.07	-0.09**	-0.03**	0.09**	-0.02*	-0.00	0.01	0.00				
12. Depression	0.16**	0.16**	-0.13**	0.12**	0.07**	-0.08**	0.09**	0.13**	0.12**	0.03**	0.12**			
13. Supervision	-0.09**	-0.04**	-0.01	-0.06**	0.06**	0.00	0.11**	-0.02	-0.05**	-0.02*	-0.06**	-0.07**		
14. Permissive	0.03**	-0.03**	-0.01	0.32**	-0.04**	0.07**	-0.05**	0.05**	0.08**	0.07**	-0.01	-0.02	-0.10**	
15. Night away	0.21**	0.20**	0.08**	0.14**	0.02	-0.02**	0.04**	0.08**	0.08**	0.03**	0.04**	0.18**	-0.09**	0.10**

* $p < .05$; ** $p < .01$

Table 2 Regression coefficients for property models (1–2) and violent models (3–4)

Variable	Property (<i>N</i> = 14,382)				Violent (<i>N</i> = 14,382)			
	Model 1		Model 2		Model 3		Model 4	
	Coefficient	<i>e^b</i>	Coefficient	<i>e^b</i>	Coefficient	<i>e^b</i>	Coefficient	<i>e^b</i>
Sleep (h)								
≤5	0.70**(0.11)	2.03	0.36**(0.12)	1.44	0.59**(0.10)	1.81	0.29**(0.10)	1.33
6	0.35**(0.06)	1.42	0.17**(0.06)	1.18	0.26**(0.06)	1.30	0.11(0.06)	1.11
7	0.19**(0.05)	1.21	0.11*(0.05)	1.11	0.03(0.05)	1.03	−0.05(0.05)	0.95
Demographics								
Male	0.57**(0.04)	1.77	0.65**(0.04)	1.91	0.79**(0.04)	2.21	0.89**(0.04)	2.43
Age	1.51**(0.33)	4.54	1.04**(0.31)	2.84	0.34(0.24)	1.41	0.13(0.22)	1.14
Age ²	−0.05**(0.01)	0.95	−0.04**(0.01)	0.96	−0.01*(0.01)	0.99	−0.01(0.01)	0.99
Hispanic	0.30**(0.08)	1.36	0.34**(0.07)	1.40	0.25**(0.06)	1.29	0.21**(0.05)	1.24
White	0.03(0.07)	1.03	0.03(0.07)	1.04	−0.28**(0.04)	0.75	−0.25**(0.04)	0.77
Poverty	−0.03(0.07)	0.97	−0.07(0.07)	0.94	0.40**(0.04)	1.49	0.35**(0.05)	1.41
Controls								
Depressive symptoms			0.04**(0.00)	1.04			0.04**(0.00)	1.04
Impulsivity			0.08**(0.01)	1.09			0.04**(0.01)	1.04
Supervision			−0.06**(0.01)	0.94			−0.02*(0.01)	0.98
Permissive			0.03*(0.02)	1.04			0.00(0.02)	1.00
Night away			0.69**(0.05)	1.99			0.54**(0.05)	1.71
Intercept	12.76**(2.72)		8.22**(2.57)		3.70*(1.92)		.91(1.79)	

Values in parentheses are standard errors. *e^b* = factor change in odds for unit increase in *x*

* *p* < .05; ** *p* < .01

8–10 h of sleep, adolescents who report 7, 6, 5 or fewer hours of sleep per night score significantly higher on the measure of property delinquency. The findings for the demographic control variables indicated that males and Hispanic youth were more likely to self-report delinquency than females and non-Hispanic youth. Further, the amount of self-reported delinquency increases with each year of age, though the significance of the age-squared variable suggests that the effect declines over time.

The inclusion of the other control variables diminishes the size of the effects of the sleep variables, however, youth who reported 7, 6, 5 or fewer hours of sleep still had significantly higher levels of self-reported property delinquency than the 8–10 h reference group. All of the additional control variables were significantly related to property delinquency. Higher scores on depressive symptoms and impulsivity measures were related to higher delinquency scores. Parental supervision was negatively related to delinquency such that more parental supervision was related to lower property delinquency scores. Parental permissiveness was positively related to property delinquency such that more permissiveness was related to more delinquency. Further, youth who had spent at least one night away from home without permission in the previous 12 months (late-night activities) were significantly more

delinquent than those youth who had not. The effects for the demographic variables parallel those presented in Model 1.

Violent Delinquency

We also proposed that sleep loss would affect violent delinquency, and Model 3 in Table 2 supports this finding. The difference between the violence and property delinquency models was that 7 h of sleep was significant in the property models but not in the violence models. Adolescents who reported receiving 6 or fewer hours of sleep were significantly more likely to self-report violent delinquency than those who received the recommended 8–10 h of sleep. Once the relevant controls were added to Model 4, the only sleep variable that remained significant was 5 or fewer hours of sleep. That is, after controlling for depressive symptoms, impulsivity, parental supervision, parental permissiveness, and late-night whereabouts, only those youth in the most deprived sleep group reported more violent delinquency than the 8–10 h reference group.

The size and direction of the demographic variables are comparable to those presented for property crime. The inclusion of the additional control variables (Model 4) showed that adolescents who had higher depressive

symptoms and impulsivity scores also had higher self-reported violent delinquency scores. Youth who had spent at least one night away from home without permission in the previous 12 months were significantly more violent than those youth who had not. Parental supervision had a relatively small, inverse relationship with violent delinquency (i.e., more supervision related to less delinquency) though parental permissiveness was not significant.

Discussion

Developmental criminology focuses on the dynamic processes that explain change and continuity of offending during a person's life. One of the most central issues developmental criminologists address is the effect of various risk factors during adolescence (Farrington 2006). Research focusing on risk factors has identified multiple domains including community, school, family, and individual levels. Developmental criminology imported the risk factor paradigm from the public health model (Farrington 2006); however, most criminological studies have either approached health problems as an outcome of criminal offending (Piquero et al. 2007) or focused on early developmental health issues such as pregnancy complications (Farrington 1997). Few criminological studies focus on offending as an outcome of poor health practices.

There is substantial evidence that problems with physical health such as minimal exercise and inadequate nutrition lead to various negative outcomes (Faulkner et al. 2007; Hillman et al. 2008; Smith and Lounsbury 2009; Valois et al. 2008). A large body of literature has documented that insufficient sleep poses significant risk and is a serious public health issue (Colten and Altevogt 2006). In light of the importance of sleep for achieving optimal health, we examined whether insufficient sleep is also a risk factor in terms of property and violent delinquency. Identifying the full range of risk factors in terms of delinquency is essential for theoretical development as well as for improving prevention and intervention strategies (Farrington 2006).

Overall, we found support for the hypothesis that adolescents who report sleeping fewer hours than recommended are engaged in more delinquency. Even after controlling for various demographic characteristics, depressive symptoms, impulsivity, parental supervision, parental permissiveness, and late-night whereabouts, we found youth who slept 7 or fewer hours reported significantly more property delinquency than did youth who slept 8–10 h. As expected, the relationship weakened as reported sleep came closer to the recommended 8–10 h with youth reporting higher property scores for 6 and 7 h, respectively. Elevated scores reflected a greater variety and prevalence

of property delinquency such that youth sleeping 7 or fewer hours per night were committing a disproportionate volume of delinquent behavior. The relationship between sleep and delinquency was not as strong for violent behavior although those who reported sleeping 5 or fewer hours did report significantly more violent behavior than those in the 8–10 h reference group.

While the findings of this study must be viewed as tentative until sufficiently replicated, we suggest that insufficient sleep results in cognitive and emotional impairments related to juvenile delinquency. Even mild sleep deprivation has immediate effects on cognitive functioning, which may increase an adolescent's risk of involvement in delinquent behavior. Specifically, less sleep disturbs cognitive functioning by altering a person's perceptions, capacity for judgment, and memory recall (Dahl 2006). Individuals with diminished cognitive functioning are prone to a broad range of poor decisions that include delinquent and criminal conduct. For example, a person who experiences cognitive impairments due to inadequate sleep may be susceptible to distorted perceptions of "immediate gratification" associated with committing a property offense (LaGrange and Silverman 1999; Swatt et al. 2008). Likewise, inadequate sleep has been shown to adversely affect a person's decision-making by elevating the expectation of gains and diminishing the perceived likelihood of loss following risky decisions (Venkatraman et al. 2007).

In terms of emotional impairment, sleep deprivation increases irritability, which increases the likelihood that an individual will respond to aversive stimuli in an aggressive manner (Caprara 1985; Caprara et al. 2007; Parrott and Zeichner 2006). Irritable individuals are more prone to violent encounters such as schoolyard fights and are at greater risk for higher levels of aggression and violence throughout adolescence (Caprara et al. 2007). Irritability reduces patience and diminishes a person's capacity to cope with frustration and other stressors. In addition, irritability may also increase the likelihood a person will interpret relatively ambiguous stimuli in a hostile manner thereby increasing the likelihood the person will engage in violent behavior (Wilkowski and Robinson 2008).

So why are there differences in terms of violent and property offending? There is substantial evidence that violent offenses are relatively infrequent as compared to property crime (Snyder et al. 2003). In terms of crime seriousness, violent offenses are consistently viewed as more harmful. The relative infrequency of violent offenses may reflect the grave nature associated with such behavior. Lower levels of sleep deprivation may not have the necessary impact on a person's cognitive functioning to facilitate violent behavior while greater deprivation may provide a level of impairment conducive to violence. Our finding about the greater level of sleep deprivation

necessary for violent offenses is consistent with a broader set of studies examining risk factors and youth violence. In general, when compared to nonviolent offenders, violent youth offenders are likely to suffer from more serious risk factors and from more risk factors across multiple domains (Appleyard et al. 2005; Deater-Deckard et al. 1998; Saner and Ellickson 1996; Watson et al. 2004).

Finally, we acknowledge that the relationship between sleep and delinquency may, in fact, be spurious. There is some evidence for a clustering of “adverse behaviors” (van Nieuwenhuijzen et al. 2009), meaning that the relationship between sleep and delinquency could be the result of another underlying factor. It is plausible that both insufficient sleep and delinquency simply reflect a lack of self control (Gottfredson and Hirschi 1990). Individuals who lack self-control are also likely to suffer from poor overall physical health (Kim et al. 2008; Reyna and Farley 2006). Individuals with self-control deficits are unable to delay gratification and engage in the type of decision-making that is necessary for achieving optimal health. This would include getting to bed at a reasonable hour and remaining in bed until sleep comes. From this perspective, insufficient sleep does not produce self-control problems, but rather sleep problems experienced by adolescents are a result of an underlying deficit in self-control. Despite this possibility, we did control for impulsivity, the central characteristic associated with low self-control, and still found significant effects in terms of sleep.

Insufficient sleep may also reflect problems in the home and/or with parental attachments. As adolescents mature, parents are less likely to set bed times (Wolfson and Carskadon 1998), and sleep deficiencies are more common in households with fewer rules regarding bedtimes and family meals (Adam et al. 2007). Previous research finds that insufficient sleep is associated with a lack of, or problematic, parental attachments (Michael et al. 2007; Scharfe and Eldredge 2001) and that family conflict predicts sleep problems among children and adolescents (Gregory et al. 2006). In controlling for parental supervision and permissiveness, we did show that sleep has an effect independent of these variables though the relationships between sleep, delinquency, and parental attachments still needs further investigation.

Limitations and Future Research

There are several limitations of our study that should be noted. First, construct measurement was constrained by the availability of indicators within the Add Health data. The delinquency scales were limited in the range of content coverage. Specifically, the scales exclude status offenses, an area that should be included in future research. Although we used a measure of impulsivity that has been

used elsewhere in the literature (Vazsonyi et al. 2006), we acknowledge that it is overly focused on decision-making and has a high threshold for which most (non-impulsive) adults may not score well. Additionally, sleep deprivation was based on one question (typical hours of sleep) and our study could be improved by a more complex measure of sleep. Many youth, for example, have different bedtimes and get varying amounts of sleep on the weekends as compared to weeknights (Roberts et al. 2009). Exploring these and other indicators could provide a more complete picture of the sleep and delinquency relationship.

We were interested in the more immediate effects of sleep on behavior (i.e., the type of impairment that can happen after just one night of sleep loss) and thus focused on the relationship at the cross-sectional level. Future researchers could shed light on a number of issues with longitudinal investigations. For example, we did not test for longer-term, indirect effects though we can foresee possible relationships of this nature. In particular, reduced sleep may result in neurocognitive functioning deficits (Dahl 1996; Keller et al. 2008), and attention problems (Blunden and Chervin 2008) leading to poor academic performance. There is a long-standing body of criminological research examining the relationship between academic performance, academic disengagement, and delinquency (see discussions in Felson and Staff 2006; Maguin and Loeber 1996). While various questions remain unanswered regarding this relationship, several studies suggest a strong link between academic underachievement and violence, delinquency, and substance use (Huizinga et al. 1998; Siennick and Staff 2008). At the same time, successful academic performance typically predicts lower rates of risk behaviors (Maguin and Loeber 1996), a finding consistent across gender, age, and race (Choi 2007; Krohn et al. 1995). Future longitudinal research needs to consider poor academic performance as a mediator between long-term sleep debt and delinquent behavior.

Child and adolescent sleep is beginning to receive significant attention as sleep behaviors, such as sleep timing, quantity, quality, and consistency have immediate consequences in terms of emotion regulation, cognitive functioning, and behavior, as well as long-term influences on psychological and physical well-being. Transitions to earlier school start times associated with moves into middle school and high school are associated with significant decreases in total sleep time for young adolescents, and thus a high prevalence of sleep-deprived teens (Carskadon et al. 1998; Wolfson et al. 2007). The effects of earlier school start times are further exacerbated by the fact that adolescents typically go to bed at approximately the same time regardless of their school start times (Carskadon et al. 1998; Dahl and Lewin 2002), a tendency driven, in part, by various biological changes and, in part, by social and academic demands.

Identifying possible risk factors, such as sleep deprivation, is a critical part of designing effective interventions for delinquency and other problem behaviors (Mrazek and Haggerty 1994). Although prevention and intervention efforts could be focused specifically around sleep hygiene, we suggest that a focus on sleep and other lifestyle factors might fit well within broader public health and resiliency approaches to prevention. The role of sleep within the realm of public health approaches to delinquency prevention/intervention requires education and collaboration of key stakeholders at various stages of the developmental process (Welsh 2005). Primary prevention efforts and research might involve more exploration into the impact of school start times on sleep and its consequences (Carskadon et al. 1998; Mitru et al. 2002; Wolfson et al. 2007) or increased education for parents and teachers about the necessity and changing needs of sleep for adolescents (Carskadon 1990). Secondary prevention efforts might include increased sleep hygiene screening by pediatricians (Rivara and Farrington 1995), other health officials, and school counselors among children and adolescents most at-risk for delinquency. Finally, increased attention might be paid to sleep and other health behaviors as part of interventions that focus on youth who are incarcerated or otherwise involved in the juvenile justice system. Again, these suggestions do not require entirely new programs; rather they could be easily integrated into already existing prevention and intervention efforts.

Conclusion

Our study furthers the existing discussion of lifestyle factors and physical health in relationship to delinquent offending by exploring the association between sleep and antisocial behavior. Our analysis provides preliminary evidence that sleep-deprived adolescents participate in a greater volume of both violent and property crime, though our explanations must remain tentative. Further, our results indicate that every little bit of sleep may make a difference. That is, sleeping 1 h less (i.e., 7 h) than the recommended range increased the likelihood of property delinquency, and this risk increased for each hour of sleep missed. Insufficient sleep increases impulsivity, irritability, and adversely affects decision-making (Dahl 2006; McKenna et al. 2007). Each of these factors is, in varying ways and in varying degrees, associated with delinquent behavior. We do not provide a definitive explanation for this relationship; rather we allude to several possible explanations, which we suggest deserve attention in future research.

We propose that the amount a person sleeps is an obvious but overlooked dimension of delinquent behavior and studies that focus on adolescent health should further investigate the effects of insufficient sleep. To better

understand the relationship between sleep and delinquency, studies should utilize longitudinal designs and data derived from time-diaries that assess both quantity and quality of sleep. Finally, we suggest that sleep and other relevant health behaviors need to be considered in the context of more comprehensive approaches to delinquency prevention and intervention.

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