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Sleep As Mediator in the Pathway From Violence-Induced Traumatic Stress to Poorer Health and Functioning: A Review of the Literature and Proposed Conceptual Model

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Abstract

Millions of children are exposed to various forms of violence every year, resulting for many of them in psychological problems, decreased social functioning, and poorer overall quality of their relationships and lives. This article reviews the scientific literature investigating the role of sleep as a key mediator in the pathway between violence-induced traumatic stress and resulting negative health and behavioral outcomes. Based on evidence revealed by this review and general research on how exposure to violence influences child health and development, a conceptual model is proposed that posits sleep's role as an important mediator of health effects and that incorporates other factors believed to shape linkages between exposure to violence and health and behavioral outcomes in children. Recommendations are given for future research to test the proposed model.

Keywords

violence; sleep; traumatic stress; mediator; children; adolescents

Introduction

Astonishing numbers of children are exposed to violence worldwide. For example, in the last decade, wars have killed or severely injured approximately 8 million children, orphaned one million children, and dislocated 12 million children from their homes ("Children in conflict," 2005; "State of the world's children," 1996). The conservative estimate of the number of children worldwide who witness domestic violence is 133 million annually ("Behind closed doors," 2006). Moreover, an estimated 150 million girls and 73 million boys are victims of sexual violence involving physical contact (Pinheiro, 2006), and results of some population-based surveys indicate that between 25-50% of children in some locations are victims of frequent, severe physical abuse, such as being beaten, kicked, or tied up by their parents (Krug, Dahlberg, Mercy, Zwi, amp; Lozano, 2002).

In the US, an estimated 15 million US children are exposed to domestic violence each year (McDonald, Jouriles, Ramisetty-Mikler, Caetano, & Green, 2006), and results of several studies suggest that anywhere from one-half to over three-quarter of children in urban areas have been exposed to community violence (Kupersmidt, Shahinfar, & Voegler-Lee, 2002; Singer, Menden Anglin, Song, & Lunghofer, 1995). Moreover, approximately 170,000 cases of substantiated or indicated child physical abuse and 88,000 cases of child sexual abuse have occurred annually since 2000 (Child Maltreatment, 2006).

Exposure to violence takes its toll on the health and well-being of children. In addition to the physical effects of bodily harm (if the children are physically assaulted during the incident), research indicates that exposure to violence may disrupt children's psychological outcomes in numerous ways (Fantuzzo & Mohr, 1999; Margolin, 1998; Robbie Rossman, 2001; Osofsky 2003). Over time, children exposed to violence may develop psychological problems ranging from sub-clinical behavior problems to diagnosable adjustment, depressive, anxiety, or posttraumatic stress disorders (Robbie Rossman, 2001; Silverman & La Greca, 2002). In turn, these problems may affect children's academic and social functioning and the overall quality of their relationships and lives (Delaney-Black et al., 2002).

Experts generally agree that exposure to violence may lead to poorer health, behavioral, or developmental outcomes. However, the specific mechanisms that account for these relationships are not yet well understood. For example, violence may affect children directly through physical harm. Also, exposure to violence may lead to subsequent behavioral problems in children through modeling/social learning processes (Mihalic & Elliott, 1997). Another mechanism through which violence may affect children is through traumatic stress, in which violence overwhelms children's psychological and biological coping mechanisms (Fletcher, 2003; Ruchkin, Henrich, Jones, Vermeiren, & Schwab-Stone, 2007).

One aspect of children's functioning affected by violence is sleep, and several publications have reviewed the literature on the characteristics of sleep disturbances arising from traumatic experiences such as violence (Caldwell & Redeker, 2005; Harvey, Jones, & Schmidt, 2003; Lavie, 2001; Pillar, Malhotra, & Lavie, 2000; Singareddy & Balon, 2002; Sadeh, 1996). Many of these reviews focus specifically on the sleep characteristics of individuals with Posttraumatic Stress Disorder (PTSD) or Acute Stress Disorder (ASD) (Harvey et al., 2003; Pillar et al., 2000; Singareddy & Balon, 2002). Sleep disturbances and these disorders are clearly intertwined; insomnia and nightmares are considered core criteria of PTSD and ASD in the DSM-IV. Evidence from neurobiological, functional neuroimaging, and animal studies indicates that PTSD is associated with increased noradrenergic levels and abnormal functioning of the amygdala and medial prefrontal cortex, areas of the brain that are involved in regulation of REM and NREM sleep and, the case of the amygdala, processing of emotional information (see reviews by Germain, Buysse, & Nofzinger, 2008; Spoormaker & Montgomery, 2008). Results of a recent meta-analysis have highlighted abnormalities in REM sleep of persons with PTSD (Kobayashi, Boarts, & Delahanty, 2007). Although the precise neurophysiological pathways are still unclear, it has been hypothesized that (1) hyperactive amygdala functioning, elevated noradrenergic levels, or both, might lead to nightmares during REM sleep (Germain et al., 2008; Spoormaker & Montgomery, 2008); and (2) hyperactivity of the amygdala and attenuated activity of the medial prefrontal cortex during NREM sleep may increase arousal and, consequently, insomnia complaints (Germain et al., 2008). Violence may also affect other aspects of sleep, including sleep disordered breathing (Krakow et al., 2002) and periodic limb movements (Brown & Boudewyns, 1996).

Similar to the large body of literature linking exposure to violence with a host of health and behavioral outcomes in children, a growing body of research has revealed associations between poor sleep and numerous aspects of children's health and well-being. Insomnia, a core sleep-related criterion of PTSD and ASD, may result in sleep deprivation, a stressor linked to multiple physiological and neurobiological changes: e.g., increased appetite and energy expenditure, increased levels of proinflammatory cytokines, decreased parasympathetic and increased sympathetic tone, increased evening cortisol levels, and increased blood pressure, elevated insulin and blood glucose levels, and brain restructuring (reviewed in McEwen, 2006). In children, sleep deprivation and other sleep disturbances or

disorders have been linked to overweight (Lumeng et al., 2007), unintentional injuries (Lam & Yang, 2007; Stallones, Beseler, & Chen, 2006; Owens, Fernando, & McGuinn et al., 2005; Valent, Brusaferrero, & Barbone, 2001), poorer behavioral and cognitive functioning (Beebe et al., 2004; Buckhalt, El-Sheikh, & Keller, 2007; Chervin, Dillon, Archbold, & Ruzicka, 2003; Fallone, Acebo, Seifer, & Carskadon, 2005), mood disorders (Fredriksen, Rhodes, Reddy, & Way, 2004); academic performance (Wolfson & Carskadon, 2003; Perez-Chada, Perez-Lloret, Videla, Cardinali, & Bergna, 2007), and quality of life (Rosen, Palermo, Larkin, & Redline, 2002). A recent prospective study of the effects of insomnia among a sample of over 4,000 adolescents revealed that chronic insomnia was associated with adverse outcomes across multiple indicators of social, somatic, and psychological functioning (Roberts, Roberts, & Duong, 2008).

Multiple mechanisms may be involved in specific sleep disorders: e.g., hypoxia or sleep fragmentation, not sleep deprivation per se, leads to decreased cognitive functioning in children with sleep apnea (Kanaan, Farahani, Douglas, LaManna, & Haddad, 2006; Row, 2007; Row, Kheirandish, Cheng, Rowell, & Gozal, 2007; McCoy et al., 2007). Regardless of whether single or multiple mechanisms are involved, non-restorative sleep is still considered an important contributor, though not necessarily the sole contributor, to the observed deficits.

Given these two associations (violence linked to negative outcomes, sleep deprivation and disturbances linked to negative outcomes), the fact that exposure to violence is linked to sleep disturbances has led to suggestions that the sleep-disturbance aspects of children's "traumatic response" to violence may be critical in the development of poorer health and behavioral outcomes (Wittman, 2007). In support of this viewpoint, a small number of studies have shown that PTSD-related sleep disturbances were significantly related to health outcomes independent of other symptoms of traumatic stress in samples of traumatized adults (Clum, Nishith, & Resick, 2000; Krakow et al., 2000, Krakow et al., 2002; Nishith, Resick, & Meuser, 2001).

The purpose of this article is to review the scientific literature investigating the role of sleep as a key mediator in the pathway between exposure to violence, development of traumatic stress, and resulting negative health and behavioral outcomes in children. The term "mediator" is used specifically to denote that sleep disturbances are an "explanatory link" accounting for the relationship between violence-induced traumatic stress and, ultimately, child health behavioral outcomes (Baron & Kenny, 1986; Rose, Holmbeck, Millstein-Coakley, & Franks, 2004). From an analytic standpoint, mediation is supported when the following criteria are met: (1) a predictor variable is significantly associated with an outcome of interest and is also associated with the proposed mediator; (2) the mediator is significantly associated with the outcome of interest after controlling for the effects of the predictor; and (3) the significant relationship between predictor and outcome is significantly reduced after controlling for the mediator's effects (Rose et al., 2004).

Based on the evidence revealed by the review, this article will present a conceptual model that posits sleep as an important mediator of the relationship between violence-induced traumatic stress and health and behavioral outcomes in children. In other words, the model suggests that the sleep disturbance aspects of posttraumatic stress play a critical role in the development of negative outcomes in children's health and well-being. The conceptual model presented here advances the existing literature on this topic in two ways: first, it is based on a systematic review of the scientific literature. Second, the model incorporates in a more comprehensive manner other factors that investigators believe play an important role in the linkages between exposure to violence, development of traumatic stress, and health and behavioral outcomes in children. Whenever possible, studies specifically involving

children are described to support hypothesized links between model components. Evidence from studies involving adults are presented to supplement findings from child-based research or to serve as evidence for hypothesized linkages in cases when the necessary research has not yet occurred in children.

The model is presented to both outline a potential causal mechanism and to stimulate research on the impact of violence on sleep. Establishing sleep as a mediator of health effects has both theoretical significance in identifying one mechanism through which exposure to violence affects children, as well as practical significance: sleep “hygiene” (e.g., sleep duration, bedtime routines) may be a feasible target for intervention to improve the behavioral, social, and psychological outcomes of children exposed to domestic violence (Kendall-Trickett, 2005; Prinz & Feerick, 2003).

Method

Systematic searches of the databases PubMed and PsychInfo were undertaken to identify relevant published studies. Search terms included the stems trauma*, viol* and sleep* as well as mediat* and path*. PsychInfo is a database that covers the national (US) and international scientific literature in the behavioral sciences and mental health since 1967 and is updated weekly. PubMed is the public-access version of MEDLINE and covers the US and international scientific literature of numerous clinical disciplines, including psychiatry and sleep medicine since 1950. The topical areas involved in this review (e.g., sleep, effects of violence, mental health) lie in both behavioral science and clinical domains, so both the behavioral-science and biomedical databases were searched in order to locate all pertinent articles. The references of studies identified through the searches were also examined in order to identify additional investigations with pertinent data. In addition, the National Institutes of Health’s Computer Retrieval of Information on Scientific Projects (CRISP: <http://crisp.cit.nih.gov>) was similarly searched to identify relevant NIH-funded research. Identified studies’ principal investigators were contacted in order to inquire whether they had published or unpublished findings that they could provide. Relevant articles were limited to those that: (1) involved persons exposed to potentially traumatic events; (2) utilized a measure of traumatic stress; and (3) tested for a mediating effect of sleep in the relationship between traumatic stress and a health, psychological, or physiological outcome.

The literature searches revealed a total of five articles that met all criteria for inclusion in the review (Cruess et al., 2003; Hall et al., 1998; Ironson et al., 1997; Mohr et al., 2003; Picchioni et al., 2007). Of note, several articles identified in the searches have examined the role of sleep as a potential mediator and have reported partial or complete mediation of health and psychological outcomes by sleep characteristics, but they have investigated exposure to events or conditions that were not considered to induce traumatic stress, or did not include in their methods a measure of traumatic stress, or both: e.g., postoperative pain and subsequent knee function (Cremins-Smith, Millington, Sledjeski, Greene, & Delahanty, 2006), socio-economic status and psychological/physical health (Moore, Adler, Williams, & Jackson, 2002; Mulatu & Schooler, 2002), racism and depressive symptoms (Steffen, & Bowden, 2006), social support and myocardial infarction (Nordin, Knutsson, & Sundbom, 2008), “daily stress” and immune function (Miller et al., 2004), emotional insecurity and children’s adjustment and academic performance (El-Sheikh, Buckhalt, Cummings, & Keller, 2007), and organizational justice and psychiatric morbidity (Elovainio, Kivimäki, Vahtera, Keltikangas-Järvinen, & Virtanen, 2003). One additional study (Meewise et al., 2005) was not included because it was unclear from the description of the methods the degree to which the sleep measure was formally tested as a mediator. Also, as mentioned previously, a small number of studies investigated the effect of posttraumatic stress-related sleep disturbances on physical or psychological outcomes independent of non-

sleep-related post-traumatic stress symptoms, but they did not test for mediation (Clum et al., 2001; Krakow et al., 2000, 2002; Nishith et al., 2001) and were therefore not included in the review.

The Conceptual Model

The conceptual model is outlined in Figure 1. The major pathway (dashed arrow) can be described as follows: (1) exposure to violence may produce a traumatic reaction or response in children; (2) this traumatic response includes both a daytime (non-sleep) and nighttime (sleep) component; (3) the nighttime component (i.e., sleep disturbances) mediates the relationship between the daytime traumatic response and child health and behavioral outcomes; (4) factors such as social support and the presence of comorbid conditions may shape children's traumatic stress response and, in the case of comorbid conditions, may lead to poor sleep directly; (5) characteristics of the children's sleep environment may also affect children's outcomes by influencing sleep quality and quantity; (6) factors related to the social environment in which the children lives, namely, cultural background and family socio-economic status, are viewed as distal factors that exert their influence by shaping other components more proximal (e.g., violence, social support) to the major pathway proposed by the model; characteristics of the children themselves, such as developmental status and gender are seen as important moderators of several pathways; (7) the presence of other life stressors apart from violence (e.g., poverty, family breakup) may, besides directly shaping health and behavioral outcomes, utilize existing social-support resources and may thereby exacerbate the effect of violence-caused traumatic stress on children. Critical model features are described in greater detail below.

Exposure to Violence

In the proposed model, the exposure of interest is violence. Although the development of a traumatic response or traumatic stress after exposure to violence is not automatic, the relationship between exposure to violence and development of traumatic stress is generally well established (Kamphuis & Emmelkamp, 2005). Different forms of violence (e.g., child maltreatment, domestic violence, community violence) tend to be compartmentalized by investigators and studied independently. However, they often occur in combination (Finklehor, Ormrod, & Turner, 2007; Saunders, 2003), and each may contribute to traumatic stress responses in children. In fact, exposure to different forms of violence may be more important than multiple exposures involving the same form of violence in development of traumatic symptoms (Finklehor et al., 2007). Thus, the model includes multiple forms of violence (i.e., interpersonal and collective). Based on World Health Organization definitions (Krug et al., 2002), interpersonal violence is considered violence inflicted by an individual or small group of individuals on another individual and includes forms of violence such as family and intimate partner violence (violence in which the individuals know each other and are often related and which typically occurs in the home, such as child abuse, spouse abuse, elder abuse) and community violence (violence often committed outside the home between individuals who are not related and who may not know each other, such as physical or sexual assault by strangers, violence in schools or workplaces). Collective violence is defined as the collective use of violence by one group or set of individuals against another group or set for political, economic, or social purposes: e.g., war, terrorism, gang warfare (Krug et al., 2002).

Moreover, because evidence indicates that increased severity (in terms of both actual level of injury sustained and perception of threat to oneself or others) and frequency of violence are important etiological factors predicting occurrence of traumatic stress symptomatology (Meiser-Stedman, 2002; Singer et al., 1995), both factors are included in the model as independent contributors to a child's traumatic stress response.

The Mediating Role of Sleep

The central feature of the model is that sleep is posited to mediate the relationship between violence-induced traumatic response in children and health and behavioral outcomes. Results of the literature review revealed a small but growing body of evidence for this pathway: results of recent studies with adults indicate that sleep (or sleep disturbances) may (1) affect outcomes independent from other dimensions or manifestations of traumatic stress; or (2) mediate the relationship between traumatic stress and health and behavioral outcomes (Table 1). Testing independent or mediating effects of sleep is challenging because sleep disturbances are themselves symptoms of traumatic stress and are included as diagnostic criteria for determining PTSD and acute stress disorder in the DSM-IV. However, to overcome this barrier, two of the investigations (Mohr et al., 2003; Picchioni et al., 2007) specifically re-defined traumatic stress or the traumatic stress response as having a daytime component, characterized by daytime symptoms and processes, and a nighttime component, characterized by nighttime symptoms and processes. Based on this redefinition, these investigators have then removed sleep-related items from their instrument(s) assessing traumatic stress in order to measure the daytime component of traumatic stress. To measure the nighttime component, investigators substituted other instruments to measure sleep characteristics (Creuss et al., 2001; Hall et al., 1998; Ironson et al., 1997; Mohr et al., 2003; Picchioni et al., 2007).

Five studies have directly examined the mediating effects of sleep on the relationship between traumatic stress and health or behavioral outcomes in adults, and all have provided evidence for sleep's mediating role. Mohr and colleagues (2003) investigated associations among subjectively reported sleep quality, traumatic stress symptoms, somatic symptoms (e.g., intensity of bodily symptoms, such as headaches, faintness, chest or heart pain, muscle soreness, lower back pain, numbness/tingling), and health functioning (degree to which physical symptoms interfere with activities) in an ethnically diverse sample of 741 police officers from 3 large, urban police departments. Results showed that after controlling for age, alcohol abuse, exposure to duty-related traumatic events, and Hispanic ethnicity, sleep quality: (a) fully mediated the relationship between traumatic stress symptoms and health functioning; and (b) partially mediated the relationship between traumatic stress symptoms and somatic symptoms.

Picchioni and colleagues' (2007) study of a group of 805 U.S. Army veterans of the Iraq war revealed that insomnia functioned as a partial mediator between combat-related stress and depression: i.e., addition of insomnia to the regression model reduced the zero-order correlation between stress and depression by 59%. Moreover, these investigators also reported that nightmares partially mediated the relationship between combat stress and PTSD.

Three studies have investigated the role of sleep in the pathway between traumatic stress and measures of immune function. Ironson and colleagues (1997) studied associations between PTSD and immune function in a sample of 172 adult survivors of Hurricane Andrew. As part of their analysis, they examined the potential mediating function of subjectively reported sleep problems (trouble falling asleep, early morning awakening, and restless/disturbed sleep) on immune functioning. Study results showed that sleep problems mediated the association between PTSD (total score) and natural killer cell cytotoxicity. Sleep problems also mediated the relationship between levels of intrusive and avoidant thoughts and natural killer cell cytotoxicity. The effect was small but significant. Standardized betas were approximately $-.20$. The investigators noted that their findings corresponded with previous research showing that sleep deprivation in normal, unstressed persons reduced natural killer cell cytotoxicity (Irwin et al., 1994).

Hall and colleagues' (1998) study of a sample of bereaved, older adults investigated sleep's role in the pathway between scores on the IES (measuring frequency of intrusive thoughts and avoidance behaviors) and immune function as indicated by the number of circulating natural killer cells in samples of participants' blood. Unlike the other studies reviewed here, these investigators utilized a combination of objective (3 nights of polysomnography) and subjective (Pittsburgh Sleep Quality Index; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) measures of sleep. They found that (a) increases in two objectively measured indices of sleep discontinuity – sleep latency and the number of minutes of wakefulness before the first REM period – were both associated with greater frequency of intrusive thoughts and avoidance behaviors; (b) number of minutes of wakefulness before the first REM period was associated with lower natural killer cell numbers; and (c) greater frequency of intrusive thoughts and avoidance behaviors was associated with decreased number of circulating natural killer cells. Tests for mediation revealed that controlling for the effects of age, the relationship between IES scores and number of natural killer cells was no longer significant once the sleep discontinuity measure was added to the regression model. Moreover, minutes of wakefulness before the first REM period accounted for 12% of the variance in natural killer cell circulation.

Creuss and colleagues (2003) studied the relationships among psychological distress, subjective sleep quality, and concentrations of two critical lymphocyte populations: CD3+ CD4+ and CD3+ CD8+ in a sample of 57 HIV-positive adults, all of whom were on combination antiretroviral therapy and 47% of whom were asymptomatic. Results of their study revealed that sleep disturbance (measured by total PSQI score) mediated the relationship between IES scores (psychological distress) and immune status as measured by CD3+ CD8+ concentration: controlling for age, CD3+ CD4+ cell concentration, and viral load, addition of PSQI to the overall regression model decreased the IES regression coefficient by nearly 50% to statistical non-significance.

Proximal Factors Affecting the Traumatic Stress –Sleep-Outcomes Pathway: Social Support, Comorbid Conditions, and the Child's Sleep Environment

The proposed conceptual model also includes other factors that the scientific literature indicates shape the development of traumatic stress and health and behavioral outcomes in children. First, research on resilience in both children and adults has revealed that positive human relationships are important in the processes leading to resilience (Luthar & Brown, 2007). The traumatic stress literature indicates that the social support obtained through such relationships may play a “protective role” by hindering the development or decreasing the severity of symptoms of traumatic stress: Results of a meta-analysis concerning risk factors for the development of PTSD in adults revealed that lack of social support was the strongest risk factor (effect size = .40) of 14 separate risk factors for the disorder, including trauma severity (Brewin et al., 2000). Similar evidence of the importance of social support as a factor shaping the development and sequelae of traumatic responses is seen in children as well (Hammack, Richards, Luo, Edlynn, & Roy, 2004; Ozer & Weinstein, 2004; Kliwer, Lepore, Oskin, & Johnson, 1998). In most studies, social support is viewed as a moderator, in which it affects the magnitude of the relationship between exposure to violence and traumatic stress, but is not part of the causal pathway through which exposure to violence leads to traumatic stress.

The presence of comorbid psychological conditions constitutes a second important proximal factor in the model. Large epidemiological studies have shown that traumatized children often have other comorbid conditions: e.g., children with clinical or subclinical PTSD who also have depression (Copeland, Keler, Angold, & Costello, 2007; Kilpatrick et al., 2001). The effects of these comorbid conditions on sleep and health and behavioral outcomes are well known (Harvey et al., 2003; Singareddy & Balon, 2002).

Besides social support and comorbid conditions, the model includes as a third proximal factor, the sleep environment itself, which may affect children's sleep and, subsequently, health and behavioral outcomes. Here, the sleep environment is broadly defined to include both biological or physical factors (e.g., excessive light or noise, room temperature, type of bedding) and social factors, such as sleep routines, parenting practices, and use of "bedroom electronics" (e.g., televisions, computers, video games, cell phones). Irrespective of the experience of violence and trauma, such aspects of the sleep environment may promote or hinder sleep quality and quantity (Dworak, Schierl, Bruns, & Struder, 2007; Meijer, Habekoth, & Van den Witenboer, 2001; Mindell & Owens, 2003; Spilsbury et al., 2005).

Moreover, results of recent research indicate that the sleep environment itself might change because of the presence (or threat) of violence: women survivors of domestic violence reported altered routines (e.g., sleeping only when a perpetrator is asleep or out of the house, sleeping fully clothed, sleeping with a weapon) and sleeping locations (changing rooms) in response to violence (Lowe, Humphreys, & Williams, 2007). Although the topic has lacked systematic investigation, similar changes in the sleep environment (e.g., changing sleep location, sleep partners, sleeping with weapons) may also occur among children (Gaffney, 2006; Kaplow, Saxe, Putnam, Pynoos, & Lieberman, 2006; Pynoos & Nader, 1988).

Important Child Characteristics

Factors related to the child (CFM in Figure 1) may also affect the model's proposed pathways and are, therefore, included in the model. For instance, evidence suggests that a child's developmental level may modify several key relationships in the conceptual model: (1) there is some evidence that older children may be less likely than younger children to develop traumatic symptoms following exposure to violence (Lehmann, 1997; Spilsbury et al., 2007); (2) changes in the size and makeup of children's social networks occur as children develop, with consequent shifts in the availability and use of different sources of social support (Belle, 1989; Garbarino, Stott, & the Erickson Institute Faculty, 1992); and (3) biological changes related to growth and puberty as well as the effects of various social factors, such as the schedule and demands of school, extra-curricular activities, and work may lead to substantially decreased sleep and subsequent daytime sleepiness, particularly among adolescents (Wolfson & Carskadon, 1998); (4) developmental level may modify the relationship between traumatic stress and health, behavioral, and cognitive outcomes (Schwab-Stone et al. 1999), though recent meta-analyses involving studies of children exposed to domestic violence have not found such effects (Kitzmann, Gaylord, Holt, & Kenny, 2003; Wolfe, Crooks, Lee, McIntyre-Smith, & Jaffe, 2003).

Similar to children's developmental level, child gender may also modify associations in the conceptual model. Several studies provide evidence that exposure to violence leads to greater level of traumatic symptomatology in girls versus boys (Paquette & Underwood, 1999; White et al., 1998), though gender's influence may vary across trauma symptoms. Gender is also posited as influencing the social support: traumatic stress association because girls' social networks may involve closer or more intensive relationships among members than do boys' networks (Rose & Rudolph, 2006). Similar to developmental level, such a difference may affect the availability and use of various forms of social support. Concerning the nighttime traumatic stress – behavioral/cognitive/health outcomes association, child gender may influence the frequency of externalizing vs. internalizing problem behaviors exhibited by child witnesses of domestic violence, though the specific effect is unclear; some studies find boys more likely than girls to display a range of externalizing and internalizing behaviors (Porter & O'Leary, 1980; Wolfe, Jaffe, Wilson, & Zak, 1985), while other studies find the reverse (Cummings, Pepler, & Moore, 1999; Spaccarelli, Sandler, & Roosa, 1994; Spilsbury et al., 2007; Sternberg et al., 1993), or no differences (O'Keefe,

1994a). Other research suggests that boys show more externalizing behaviors and girls more internalizing (Yates, Dodds, Alan Soufre, & Egeland, 2003).

Distal Factors – Socio-economic Status (SES) & Cultural Background

A child's (family's) socio-economic status (SES) and cultural background are both considered distal factors that affect other components of the model. SES may exert an effect at various points in the model. First, although all forms of violence may be experienced by anyone, research indicates that lower SES is associated with greater exposure to family and community violence (Fantuzzo & Mohr, 1999; Stein, Jaycox, Kataoka, Rhodes, & Vestal, 2003) as well as greater exposure to multiple forms of violence (Finklehor et al., 2007).

A second model component potentially shaped by SES is social support: evidence suggests that persons with greater SES may have greater levels of perceived social support, at least among adults (Mickleson & Kubzansky, 2003; Turner & Marino, 1995). Third, living conditions of low SES families generally involved greater crowding and decreased housing quality compared to families of higher SES (Evans, 2004), which may negatively affect sleep. Conversely, families of higher SES may be able to more easily provide their children with "bedroom electronics," which may negatively affect sleep quality and/or quantity (Mindell & Owens, 2003).

Similar to SES, children's cultural background is also conceptualized as a distal factor to traumatic stress that influences other variables in the model. First, cultural background may shape the configuration of one's social network and influence the expectations and types of social support offered by different members of an individual's social network (Nestmann & Hurrelmann, 1994). Second, a growing body of research is illuminating ethnic/cultural differences in children's sleep regardless of exposure to traumatic events: Aspects of children's sleep, such as bedtime routines, use of sleep aids, napping, sleeping arrangements, expectations about sleep need, decisions around what constitutes sleep "problems" and the solutions to those perceived problems are shaped by culture (Jenni & O'Conner, 2005, Worthman & Melby, 2002; Milan, Snow, & Belay, 2007). Thus, cultural background may influence the child's sleep environment.

Other Stressors

Although the model focuses on the effects of violence-induced traumatic stress, exposure to violence is only one of several chronic stressors typically faced daily by children and families of low SES: e.g., substandard housing, poor schools, environmental hazards, inadequate municipal and health services, less accessible retail and service merchants (Evans, 2004). These stressors also consume resources (e.g., social support) and contribute to "allostatic load": i.e. wear and tear on the body that results from chronic stress (McEwen, 1998). They therefore constitute critical components of the social context in which so many children exposed to violence live. As conceptualized in the model, these stressors may have their own effects on child sleep and health/cognitive/behavioral outcomes, and they may also exacerbate trauma arising from exposure to violence.

Recommendations for Research to Test the Sleep-As-Mediator Model

The existing studies to date have made an important contribution to the field by providing intriguing, preliminary evidence for the role of sleep as mediator. Four main recommendations are provided to further knowledge in this area:

Recommendation 1: Improve measurement of sleep and traumatic stress variables

To date, measurement of variables such as sleep and traumatic stress in the sleep-as-mediator literature has been somewhat limited. Concerning sleep parameters, only one of the five studies reviewed in this article (Hall et al. 1998) included an objective measure of sleep. Inclusion of both subjective and objective measures of sleep is important because they differentially relate to traumatic stress; the observed incongruency between subjective and objective measures of sleep among traumatized individuals is a consistent finding (Lavie, 2001; Pillar et al., 2000). Use of both types of measures would provide greater assessment of a participant's overall sleep "experience" after a potentially traumatic event.

Moreover, to accurately assess the relationship of sleep to other study variables, the type of sleep parameters investigated should be expanded from frequency of nightmares and insomnia to include aspects such as sleep duration or sleep efficiency (proportion of time in bed that is actually spent asleep) as well as sleep architecture (e.g., time spent or % time spent in specific sleep stages, REM characteristics such as latency or density). Although interrelated, these parameters all reflect different aspects of sleep and, therefore, might well be differentially related to both exposure and outcome variables. In this regard, when using instruments such as the Pittsburgh Sleep Quality Index, which provides both a total sleep problems/quality score as well as individual dimension (e.g., sleep latency, quality, duration, daytime dysfunction) use of both the aggregate and individual scores in analyses would potentially help identify differential effects of various sleep dimensions in hypothesized pathways.

Concerning measurement of traumatic stress, future research in this area would benefit from the use of physiological measures of stress. All studies reviewed in this paper utilized psychological measures (e.g., the IES, the PTSD symptom scale) only. However, a wide range of physiological measures is currently available (e.g., salivary cortisol, heart rate variability, blood pressure, catecholamine levels) and in the case of salivary cortisol, inexpensive as well (Hanrahan, McCarthy, Kleiber, Lutgendorf, & Tsalikian, 2006). Incorporation of biological stress markers would permit investigators to obtain a more complete assessment of an individual's physiological and psychological response to a potentially traumatic event. Use of physiological markers might also enable investigators to detect small but potentially important reactions to stress that are not of a significant magnitude to manifest via a psychological measure.

Recommendation 2: Clarify the temporal relationship among traumatic stress, sleep, and outcome variables in the model

As has been previously pointed out (Atkinson, 2003), the temporal relationship between exposure to a potentially traumatic event, psychological distress from that exposure, sleep characteristics, and outcomes of interest must be clear in order to confirm sleep's role as a mediator. None of the investigations reviewed in this paper established the temporal relationships in the pathways studied; all the studies were cross-sectional in nature, so the temporal relationship between psychological trauma and sleep disturbance or between sleep disturbance and the study outcomes(s) is uncertain. It is possible, for instance, that the sleep characteristics observed in the studies actually resulted from the health and behavioral outcomes studied. Thus, longitudinal studies are needed to clarify temporal relationships among study variables.

Recommendation #3: Expand the scope of the research to include other important modifying factors, study populations, and outcomes

Research to assess the role of sleep in the causal pathway linking exposure to violence, traumatic stress, and health and behavioral outcomes needs to identify and account for the

effects of other factors that may shape these relationships. In the conceptual model proposed here, the potential roles of distal and proximal factors such as social support, child gender, the sleep environment, socioeconomic status, and cultural background are noted. Perhaps sleep's role as a mediator is differentially expressed by child gender or level of social support. Inclusion of these factors in study designs will enable investigators to gauge their importance in the causal pathway from exposure to violence to negative health and behavioral outcomes. In a related vein, expanding the scope of the research also entails inclusion of potential confounding variables in the study design. For example, other psychological co-morbid conditions (e.g. depression, anxiety) could confound relationships among variables. Only inclusion of these factors in study designs will enable investigators to gauge their importance in the causal pathway from exposure to violence to negative health and behavioral outcomes.

Research investigating the potential mediating role of sleep also needs to include children in the study population. Because children's and adults' manifestations of and responses to traumatic stress are not identical (Scheeringa, 2004), factors mediating between traumatic stress and health/behavior outcomes may differ across the lifespan. Thus, developmental level may constitute an important modifying factor and should be investigated in future research.

Concerning study outcomes, those examined in the investigations reviewed above have consisted of health functioning, depressive symptoms, and immune status or function. Such outcomes are clearly important to child and adolescent well-being. Yet, studies involving children and adolescents have also highlighted the effects of sleep deprivation or restriction on attention, memory and learning (Sadeh, Gruber, & Raviv, 2003; Steenari et al., 2003), including academic performance (Fallone, Acebo, Seifer, & Carskadon, 2005; Fredriksen et al., 2004; Wolfson & Carskadon, 1998), as well as behavioral problems such as impulsivity, aggression, and delinquency (Haynes et al., 2006; Liu & Zhou, 2002; Sadeh, Gruber, & Raviv, 2002; Touchette et al., 2007). Future research should investigate the degree to which sleep mediates relationships between traumatic stress and neurocognitive and behavioral functioning as well.

Recommendation #4: Test interventions to improve sleep of traumatized individuals

Ultimately, the goal of a theoretical model such as the one proposed here is to guide future interventions. Thus, a final research recommendation is to test interventions specifically designed to improve the sleep of children traumatized by violence. Recent studies have indicated that interventions designed specifically to reduce nightmares and other sleep disturbances in adults with PTSD improve both individuals' sleep and daytime PTSD symptoms (Forbes et al., 2003; Germain, Shear, Hall, & Buysee, 2007; Krakow et al., 2001; Raskind et al., 2003). Less evidence is currently available concerning their effectiveness in children. Future research in this area could demonstrate the utility of selecting sleep (including the sleep environment) as a target that would improve traumatized children's symptoms and lead to improved physical and psychological health. Moreover, given the difficulties in conclusively establishing most "causative relationships," the strongest evidence of sleep's key role in the pathway between violence, traumatic stress, and children's subsequent health and behavior might be produced by detecting changes in those health and behavioral outcomes when sleep is improved.

Conclusion

This article has proposed a model highlighting the key role sleep disturbance may play in the pathway leading from traumatic stress to adverse health and behavioral outcomes. Currently, the data to support critical aspects of the model, especially among children, are limited. It is

hoped that the four recommendations described above will encourage future research in this area. For the many children traumatized by violence each year, research to identify key mechanisms of adverse effects and to guide effective interventions cannot come soon enough.

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COL=Collective Violence, CFM = Child Factor Moderators (Age, Gender), INT=Interpersonal Violence

Figure 1.
Model Conceptualizing Sleep Disturbance as A Key Pathway (dashed & bolded) between
Violence-Induced Traumatic Stress & Adverse Child Outcomes

Table 1

Investigations of Sleep as Mediator between Traumatic Stress and Health Outcomes

First Author	Event	Study Design & Sample	Age (y) Mean±SD or Range	Education	"Daytime" Traumatic Response Measure	"Night time" Sleep Disturbance Measure	Outcome Measure	Key Results
Mohr, 2003	Police work	Cross sectional 741 police officers	37.1±6.9	100% HS 68.2% College degree	Traumatic stress symptoms = MSCV minus sleep and physical health items	Sleep problems = PSQI	Health functioning = Physical Composite Score SF-12 Somatic Symptoms = SCL-90-R-SS minus sleep items	Controlling for age, alcohol abuse, Hispanic ethnicity, exposure to police related critical incidents: <ul style="list-style-type: none"> Sleep problems fully mediate relationship between traumatic stress symptoms and health functioning. Traumatic stress $\Delta R^2 = .003$, $p = .23$; sleep problems $\Delta R^2 = .061$, $p < .001$ Sleep problems partially mediate relationship between traumatic stress symptoms and somatic symptoms (45% reduction, from $R^2 = .15$ to $.08$)
Picchioni, 2007	Combat	Cross sectional 805 U.S. army Iraq war veterans	18-40+	36% HS 21% College degree	Author derived stress scale	Insomnia = sum of 3-item author derived scale (initiation, maintenance, early morning)	Depression = PHQ-DS minus sleep items	<ul style="list-style-type: none"> Stress and depression $r = .20$ ($p < .05$); when insomnia added to model, stress and depression $sr = .07$, a 59% decrease. Insomnia and depression $r = .57$; insomnia and depression $sr = .54$ with stress in model.
Ironson, 1997	Hurricane	Cross sectional 173 adults	18-71	95% HS 44% College degree	Author derived PTSD scale based on DSM-III-R criteria. Intrusive & avoidant thoughts = IES total score	Sum of 3 items from SCL-90-R: changes in insomnia, early morning awakening, restless/disturbed sleep	Immune function = NKCC	<ul style="list-style-type: none"> Onset of sleep problems mediated relationship between: (a) PTSD and NKCC ($\beta = -.22$); and (b) Intrusive & avoidant thoughts (IES) and NKCC ($\beta = -.19$)
Cruess, 2003	HIV Disease	Cross sectional 57 adults	38.8±8.5	NR	Intrusive & avoidant thoughts = IES total score	Sleep quality = PSQI	Immune status = CD3+CD8+ cell counts	<ul style="list-style-type: none"> Relationship between stress (IES) and immune status became nonsignificant when sleep quality added to model: $\beta = -.29$, adjusted $R^2 = .11$, $p < .03$ before addition; $\beta = -.15$, adjusted $R^2 = .13$, $p > .20$ after addition Relationship between sleep quality (PSQI) and immune status remained significant ($\beta = -.38$, adjusted $R^2 = .23$, $p < .01$) Variance explained in immune status increased from 11% to 23% when sleep quality (PSQI) added to model;

First Author	Event	Study Design & Sample	Age (y) Mean±SD or Range	Education	"Daytime" Traumatic Response Measure	"Night time" Sleep Disturbance Measure	Outcome Measure	Key Results
Hall, 1998	Death of Spouse or other relative	Cross sectional	40-78	NR	Intrusive & avoidant thoughts = IES total score	Sleep quality = PSQI Sleep latency & time spent awake during NREM-1 from 3- nights' PSG	Immune competence = natural killer cell count	<ul style="list-style-type: none"> Stress (IES) and natural killer cell count $pr = -.49$ ($p < .01$); Time awake in NREM-1 and natural killer cell count $pr = -.40$ ($p < .05$). Relationship between stress and immune competence no longer significant when time awake in NREM-1 added to model ($R^2 = .47$, $F = 2.22$, $p < .01$); Time spent in NREM-1 accounted for 12% variance in sleep latency ($p < .05$).

β = standardized regression coefficient. HS = High School graduate. IES = Impact of Event Scale (Horowitz, Wilner, & Alvarez, 1979). MSCV = Mississippi Scale-Civilian Version (Marmar, Weiss, Metzler, Ronfeldt, & Foreman, 1996). NKCC = Natural Killer Cell Cytotoxicity (Hercend, et al., 1985; Ironson et al., 1990). NR = Not Reported. PHQ-DS = Patient Health Questionnaire Depression Subscale (Kroenke, Spitzer, & Williams, 2001). pr = partial correlation. PSG = polysomnography. PSQI = Pittsburgh Sleep Quality Index (Buysse et al., 1989). SCL-90-R-SS = Symptom Checklist 90-item Revised Somatization Subscale (Derogatis, 1994). SF-12 = Short-Form 12-item Health Survey (Ware, Kosinski, & Keller, 1996). sr = semipartial correlation.