

**SLEEP PATTERNS AND RISK OF INJURY AMONG
RURAL MINNESOTA ADOLESCENTS**

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DEDICATION

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ABSTRACT

Sleep occupies a third of our lives; yet, only of late has credit been given to the significant role it plays in our health and well-being. Teens often are limited in the duration of sleep acquired, due to time-consuming activities, as well as biological and environmental aspects of adolescence. The current study explores potential risk of injury among teens by examining associations between sleep patterns, sleep duration, and injury.

Youth at Work, an open cohort from 41 rural high schools in Minnesota, followed 15,002 students from 2001-2003. Data were collected through a self-completed questionnaire, distributed to each student four times during the 2001-2002 and 2002-2003 school years. Questionnaire responses described events in either the summer months (fall administration) or the school year (spring administration). A total of 41, 272 questionnaires were completed. Analysis included odds ratios (OR) and 95% confidence intervals (CI) calculations using logistic regression, controlling for potential confounders by means of directed acyclic graphs.

Results indicated that adolescents who reported sleeping six hours or less every night during the summer had an increased risk of injury (OR = 1.40; CI = 1.13, 1.72). Risk of injury increased further for individuals who slept six hours or less during the weekend nights in the summer, but received optimal sleep on weeknights (OR = 1.60; CI = 1.20, 2.14). During the school year, students who reported six hours of sleep or less during school nights and sub-optimal sleep on weekend nights also had an increased risk of injury (OR = 1.53; CI = 1.07, 2.20), as did individuals who slept nine hours or longer

on weekend nights but acquired insufficient sleep on school nights (OR = 1.71; CI = 1.22, 2.39).

Among working adolescents, teens employed in entertainment who routinely slept six hours or less or greater than six hours but less than nine hours, had the greatest risk of work-related injury, compared with well-rested teens in this occupation (OR = 3.61; CI = 1.17, 11.09). Construction workers who slept either insufficient or sub-optimal hours also were nearly three times as likely to be injured as teens sleeping optimal hours (OR = 2.69; CI = 1.19, 6.06). Among farmers, risk of injury doubled for young adults who had insufficient sleep some nights, but slept optimally other nights (OR = 2.05; CI = 1.37, 3.07).

Improved knowledge of these associations and potential risks could help to target intervention efforts for the prevention of injuries among adolescents.

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ORGANIZATION

The organization of this thesis provides initial chapters including an introduction, a comprehensive literature review, and a comprehensive presentation of the research design and methods. These chapters are followed by two papers (Chapters 4 – 5), which report the major findings from the study, as well as a Discussion section (Chapter 6). Because the papers are prepared for publication in peer-reviewed journals, there is some redundancy with the first three chapters, pertinent to the literature cited and the methods presented, and the final chapter, pertaining to study validity and conclusions.

CHAPTER 1

INTRODUCTION

Sleep occupies a third of our lives; yet, only of late has credit been given to the significant role it plays in our health and well-being. It is generally believed that humans need one hour of sleep for every two hours of wakefulness, and a full spectrum of health consequences may result from accumulating sleep debt (Dement, 1999). For example, health concerns, such as obesity, hypertension, and increased emotional behaviors have been linked to decreased sleep duration (Gangwisch *et al.*, 2006; 2007, Hasler *et al.*, 2004, Dahl and Lewis, 2002). At no time in human development is this more important than in adolescence.

Adolescence is a time of great developmental change, from a physical, psychological and social perspective (Richardson and Tate, 2002). One aspect of this change is an alteration in sleep patterns; young adults, compared to preadolescents, undergo a shift in sleep-wake cycles, such that they stay up later in the evening and prefer to sleep later in mornings (Carskadon, 1993, Fukuda and Ishihara, 2001). This circadian phase delay is believed to be both biological and environmental in nature, since the teen years involve increased time constraints due to work, school and social commitments as well as major endocrine alterations (Dornbusch, 2002, Giannotti *et al.*, 2002).

The sleep patterns of adolescents have generated significant community concern in recent years, prompting high schools to re-evaluate scheduling and school start times to try to minimize sleepiness during classes (Carskadon, 2002). While young adults

appear to suffer from increased sleep deprivation, it is unclear how this lack of sleep may impact other aspects of adolescent life, including their health and safety.

Sleepiness has been identified as a risk factor for injury events among adults, often related to driving (Connor *et al.*, 2001; Lyznicki *et al.*, 1998). Insufficient sleep also has been linked to a 61% increase in injury among rural adults (Choi *et al.*, 2006). Among younger children, several studies report that those individuals who did not get enough sleep sustained a higher number of medically-attended injuries (Koulouglioti *et al.*, 2008; Valent *et al.*, 2001). Among adolescents living on farms in Colorado, sleep patterns associated with increased risk of injury included oversleeping, falling asleep in afternoon class, staying up past 3:00 am, and sleeping less than an average of 8.5 hours per night (Stallones *et al.*, 2006). Decreased sleep as a risk factor for injury also was assessed among high school students in China by Lam and Yang (2007); adolescents who slept less than seven hours per night during a normal school week were two times more likely to have experienced multiple episodes of unintentional injury than those who slept seven hours or more. Yet, further study is needed to understand the role of sleep and its association with injury, in general, among adolescents.

Work-related injury is also a major concern for adolescents. Among adolescents, work is the fourth leading cause of injury and, by age 17, it is the leading cause (Brooks *et al.*, 1993). Types of injuries commonly suffered by adolescents include lacerations, contusions, abrasions, strains and strains, fractures, and dislocations (Runyan *et al.*, 2000). Data sources for these injuries are typically emergency department records, industry self-reported data, and youth self-report; however, the true burden and

determinants of work-related adolescent injury, and especially the impact of sleep, is not well understood.

This research examines the effects of sleep, time-consuming work habits, and the risk of injury among adolescents. The aims of this dissertation were to: (1) Identify associations between different sleep patterns of rural adolescents and their risk of injury, and (2) Determine whether sleep quantity among working adolescents impacts risk of injury, especially in the diverse occupational environments to which they are exposed. Improved knowledge of these associations and potential risks could help to target intervention efforts for the prevention of injuries among adolescents.

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CHAPTER II

BACKGROUND AND SIGNIFICANCE

Overview

This chapter describes the body of literature pertaining to sleep and health, adolescent sleep habits, sleep and work-related injury experiences and, finally, sleep-deprived adolescents and injury. Based on the matrix method described by Garrard (2004), tables summarizing design and major findings of studies examining these topics are presented at the end of this chapter. Finally, the limitations in current knowledge that will be addressed by this dissertation will be discussed.

Sleep and Health

Over the past century, Americans have reportedly reduced their sleep time by approximately 20% (Dement, 1999). By 2004, the National Center for Health Statistics reported that almost one-third of all adults reported getting less than six hours of sleep per night (MMWR, 2005). Given that the current definition of insomnia emphasizes sleep durations of less than 6.5 hours, this shift is noteworthy. Sleep occupies a third of our lives, yet only of late has credit been given to the significant role it plays in our health and well-being.

It is generally believed that humans need one hour of sleep for every two hours of wakefulness, and a full spectrum of health consequences may result from accumulating sleep debt (Dement, 1999). Sleep studies find that sleepiness increases with even a small reduction in nightly sleep amounts (Dinges *et al.*, 1997). Furthermore, chronic sleep loss

degrades nearly every aspect of human performance, and unlike total sleep deprivation, which usually is short term, sleep restriction is prevalent in our society for many reasons, including medical conditions, sleep disorders, and lifestyle choices such as shift work, prolonged work hours, or jetlag (Banks and Dinges, 2007).

Several health factors have been associated with short sleep duration, as sleep has been found to act as an important modulator of neuroendocrine function and glucose metabolism (Van Cauter and Knutson, 2008). Using data collected for the first National Health and Nutrition Examination Survey (NHANES I), Gangwisch and colleagues assessed the role of short sleep duration on several health outcomes. Subjects who slept five hours or less per night more than doubled their risk of hypertension (Odds Ratio (OR) = 2.10; 95% confidence interval (95% CI) = 1.58, 2.79), and also were significantly more likely to have incidental diabetes (OR= 1.47, 95% CI = 1.03, 2.09), compared with adults sleeping at least seven hours per night (Gangwisch *et al.*, 2006, 2007). Similar results were documented by Mallon *et al.* (2005) for incidental diabetes among men (OR = 2.8, 95% CI = 1.1, 7.3). Women reporting new diabetes diagnoses at follow-up, however, reported longer sleep duration (greater than nine hours per night) more often at baseline than women not developing diabetes (7.9% vs. 2.4%, $P = 0.05$). This effect also was observed in a study from the Nurses' Health Study (Ayas *et al.*, 2003). Compared with women sleeping eight hours per night, a significant positive association between women sleeping nine hours or more and the development of diabetes persisted even after controlling for Body Mass Index (BMI), age, smoking status, hypertension, alcohol consumption, physical activity, menopausal status, depression, family history of diabetes, history of hyper-cholesterolemia, shift work, and snoring (Ayas *et al.*, 2003). Ayas and

fellow researchers also used the Nurses' Health Study data to determine whether decreased sleep duration was associated with an increased risk of coronary events in women; for individuals reporting five or fewer, six, and seven hours of sleep, relative risks were 1.82 (95% CI =1.34, 2.41), 1.30 (1.08, 1.57), and 1.06 (0.89, 1.26), respectively, using eight hours of sleep per night as referent. The relative risk for nine or more hours of sleep was 1.57 (1.18, 2.11).

Acute disease patterns also are affected by a reduction in sleep. Sleep deprivation has been shown to reduce the response to antibody production following vaccinations, leading to poorer response to infectious challenges and a higher rate of clinical illness (Spiegel *et al.*, 1999). Even the common cold becomes a challenge for the sleep deprived; a study examining sleep habits and susceptibility to rhinovirus found that participants with less than seven hours of sleep were 2.94 times (95% CI = 1.18, 7.30) more likely to develop a cold than those with eight hours or more of sleep (Cohen *et al.*, 2009).

Behavioral consequences from lack of sleep also have been noted. Sleep loss has been shown to affect oculomotor responses, leading to lapses of attention and decreased neural responsiveness (Russo *et al.*, 2003). Psychomotor vigilance task (PVT) assessment studies by Belenky and colleagues (2003) found that with sleep restriction of three hours per night for seven days, speed of response to tasks declined steadily across the study period. In subjects sleeping for five hours or subjects sleeping for seven hours, the speed of task performance declined initially, then stabilized at the reduced level. Return to full PVT speed from this sleep deficit was not fully seen within a three-day recovery period. These findings indicated that the minimum amount of nightly sleep

required to maintain daily functioning at a stable, albeit reduced, level was approximately four hours per night. But few researchers consider this maintenance level acceptable.

From a psychological perspective, sleep and mental health are so intertwined that one cannot exist without the other; good sleep sets up the brain for positive feelings, and less stress leads to better sleep (Dement, 1999). Using a Profile of Mood States (POMS) questionnaire, Dinges and researchers (1997) assessed mood disturbances among sleep-deprived subjects. The overall scores showed that restricted sleep for two nights brought on feelings of unhappiness, mental and physical exhaustion, stress, and complaints of illness and anxiety.

Overall, the state of sleep debt is associated with decreased glucose tolerance, obesity, hypertension, coronary disease, acute disease occurrence, mood swings, and the inability to perform at an optimal level, either physically or mentally. Despite these clear risks, sleep duration continues to decline.

Sleep, Health, and Adolescents

At no time in human development is sleep more important than in adolescence, for teens are undergoing changes, at the physical, psychological, and social levels (Carskadon, 2002). Many concerns, including obesity, cognitive impairment, and emotional behaviors, have been linked to decreased sleep duration among adolescents (Van Cauter and Knutson, 2008; Curcio *et al.*, 2006; Dahl and Lewis, 2002).

Although it has been clear for more than three decades that high school students obtained inadequate sleep, research linking short sleep duration with health concerns in adolescents began when adolescent sleep and waking behaviors were associated with

daytime sleepiness, depressive moods, and poorer academic performance. Students who described themselves as struggling/failing in school reported that, on school nights, they obtained 25 minutes less sleep and went to bed on average 40 minutes later than A/B students (Wolfson and Carskadon, 1998). Dahl and co-workers (2002) have studied the interaction between sleep and depression extensively, as sleep complaints are common among adolescents diagnosed with major depressive disorders. Depressed adolescents often have difficulty falling asleep, are unable to get up in the morning, and complain of fatigue. Yet complaints of depressed mood also are common in surveys of adolescents who reported less than six hours of sleep each night. Vicious cycles like those seen with emotional behaviors and sleep deprivation also are common with other health concerns.

In 2008, the Centers for Disease Control and Prevention reported that the rate of obesity in children in the United States had almost tripled in the past three decades, yet the causes of this increase cannot fully be explained by expected lifestyle factors (CDC, 2008). The Sleep Debt Study at the University of Chicago demonstrated that sleep deprivation caused decreased glucose tolerance and other endocrine alterations in young men, as well as an increase in appetite, leading to a logical link with obesity in children and adults (Spiegel *et al.*, 1999, 2004). The link between obesity and short sleep duration also was assessed in a cohort study, which found that young adults were over seven times more likely to be obese if they chronically slept less than six hours per night (Hasler *et al.*, 2004).

Young adults, compared to pre-adolescents, appear to undergo a shift in sleep-wake cycles, such that they stay up later in the evening and prefer to sleep later in mornings (Carskadon, 1993; Fukuda and Ishihara, 2001). In a study of students with

different school schedules, Valdez *et al.* (1996) determined that prolonged sleep during weekends may be the result of decreased sleep during the weekdays, due to school schedules, but also may be associated with this circadian phase delay. Adolescents in Italy who were classified as evening types, that is, those who showed a preference for sleeping at later hours and found it difficult to get up in the morning, more frequently reported napping during school days, daytime sleepiness, attention problems, poor school achievement, more injuries, greater emotional problems, and an increased use of caffeine and sleeping aids (Giannotti *et al.*, 2002).

This circadian phase delay is believed to be both biological and environmental in nature, since the teen years involve increased time constraints due to work, school, and social commitments, as well as major endocrine alterations (Dornbusch, 2002; Giannotti *et al.*, 2002). The relationship between biology, environment, and sleep was examined by LeBourgeois *et al.* (2005). This research determined that sleep quality was multi-dimensional and required both good internal factors (biological, maturational health, and psychosocial factors) and external factors (family, environment, and culture). This study also showed that sleep hygiene was a good predictor of sleep quality in American and Italian adolescents. Factors associated with good sleep hygiene included: a regular sleep-wake cycle; suitable sleeping environment; and a good bedtime routine to prepare the adolescent for sleep. Fukuda and Ishihara (2001) surveyed students ranging in age from 12 to 18 and determined that total nocturnal sleep time decreased during adolescence, as students increasingly delayed bedtime while continuing to rise at a constant time. This sleep debt has been associated with increased sleepiness and significant cognitive, emotional, and somatic complaints (Dinges *et al.*, 1997).

Sleep habits reflect many different patterns, depending on culture, country, and ethnicity (Rona *et al.*, 1998). Adolescents in different countries have shown a difference in duration of sleep time. Asian young adults appear to get the least amount of sleep, with averages between 4.8 and 7.5 hours seen among Japanese, Chinese, and Korean students (Tagaya *et al.*, 2004; Yang *et al.*, 2005). Sleep patterns in Iran are more like patterns in the United States, with a mean duration of sleep of 7.7 hours per night (Ghanizadeh *et al.*, 2008). Daytime sleepiness and napping peaked among adolescents in Iceland, when approximately 40% of 15 to 20 year-olds took a nap during weekdays (Thorleifsdottir *et al.*, 2002). Tynjala *et al.* (1993) noted that adolescents from other Northern European countries also reported extended hours of sleep; young adults in Switzerland required more than nine hours of sleep, and Finnish adolescents have a shorter nocturnal sleep than young adults in other countries in Europe.

Gender also has a potential role in sleep duration and quality. In a study of Italian high school students, differences in sleep patterns between genders were reported; more girls than boys reported poor sleep quality, including long periods of being awake at night and early awakening (Giannotti and Cortesi, 2002). Among Chinese adolescents, males sleeping less than seven hours per night experienced less risk for unintentional injury than females (Lam and Yang, 2007).

Work, Injury, and Adolescents

In the United States, work patterns begin at an early age; 57% of young men and women interviewed for the National Longitudinal Survey of Youth (NLSY) reported having held some type of job while they were 14 years old (NLSY, 1997). In 1999-

2000, 60% of 16 year-olds, 68% of 17 year-olds, and 78% of 18 year-olds were working (Bureau of Labor Statistics, 2003). Approximately 62% of employed youth between the ages of 15 and 17 worked in the retail industry, including restaurants, grocery stores, and department stores during the school months of 1996-1998 (Current Population Survey, 2000). Nationally, about 25% of youth were employed in the service industry, including lawn care, babysitting, and newspaper delivery, and agriculture employed about 8% (CPS, 2003). These young adults spent approximately 17 hours per week during the school year and 24 hours per week during the summer months at work (BLS, 2003). These rates have declined sharply over the last several years, however. In 2005, the labor participation rate had fallen to 43.7%, and during the school months of 2007, the percent of employed teenagers had fallen to 33.2% (BLS, 2008). This decline has been attributed to several factors, including increased enrollment, greater school pressures from changing graduation requirements, and an increase in volunteer activities (BLS, 2008).

Among adolescents, work is the fourth leading cause of injury, and by age 17, it is the leading cause (Brooks *et al.*, 1993). Data sources for these injuries are typically emergency room records, industry self-reported data, and youth self-reports; however, the true burden and determinants of adolescent injury is not well understood. Types of injuries commonly incurred by adolescents include lacerations, contusions, abrasions, strains and sprains, fractures, and dislocations (Runyan *et al.*, 2000).

Belville *et al.* (1993) evaluated 9,656 adolescent work injuries reported to the New York Department of Labor. Agriculture, in which only 3% of working adolescents were employed, was the second most hazardous industry overall and accounted for the highest injury rates among 16 and 17 year-old workers (67.2/10,000 and 72.3/10,000,

respectively). The majority of injuries occurred on dairy farms (39%) and crop-producing enterprises (37%). Regional data also indicated that dairy farming significantly increased the risk of agricultural activity-related injury (Boyle *et al.*, 1997).

Cogbill *et al.* (1985) evaluated 105 cases of children admitted to a regional Wisconsin hospital as a result of agricultural trauma. Injuries were related to animals for 42 children (40%), tractors or wagons for 28 children (26%), and other machinery accounted for 21 cases (20%). A similar injury pattern was seen in a study of non-fatal injuries on eastern Ontario beef and dairy operations (Brison and Pickett, 1992). In a study of 3,641 injuries in a rural Swedish municipality, childhood (ages 0-14) injuries on agricultural operations accounted for 56% of all injuries. Although most of the injuries in the community occurred within the home environment, for adolescents and young adults (ages 15-24), approximately 60% of all injuries were incurred at work.

Sleep Patterns and Injury Occurrence

Headline events, such as the *Exxon Valdez* disaster and the space shuttle *Challenger* explosion, have been linked to human error due to severe sleep deprivation (Dement, 1999). Historically, research linking sleepiness as a risk factor for injury events gained momentum when drowsiness was identified as a principal reason behind many of these catastrophic industrial and auto-related events (Mitler *et al.*, 1988).

Sleepiness has been described as a weak, but suggestive, contributing factor to increased injury among drivers (Connor *et al.*, 2001). Although Lyznicki and colleagues (1998) estimated that driver sleepiness was linked to fewer than 3% of all motor vehicle crashes in the United States, researchers with the National Commission on Sleep

Disorders estimated that drowsiness may be involved in up to 54% of all traffic events (Leger, 1994). Near-miss injury events due to dozing off were reported among 17% of 317 commercial drivers from a trucking company in Finland (Hakkanen and Summala, 2000). Individuals with sleep apnea, a cause of sleepiness, were found to be seven times more likely (OR = 7.2; 95% CI = 2.4, 21.8) to be involved in an injury-causing traffic event than individuals without sleep apnea (Terán-Santos *et al.*, 1999).

Sleep apnea symptoms also have been related to injury incidence among Kentucky farmers. Analysis of the Farm Family Health and Hazard Surveillance Project found that among part-time farmers with sleep habits consistent with poor sleep quality, risk of injury more than doubled (OR = 2.48; 95% CI = 1.13, 5.41) compared with individuals without apnea symptoms (Spengler *et al.*, 2004). Insufficient sleep among rural adults also was evaluated by Choi and colleagues (2006). While sleep-quality indicators such as snoring frequency and severity and daytime sleepiness were not found to be significant predictors of injury in a population from rural Iowa, sleeping less than 7.5 hours per night increased risk of injury by 61% compared with individuals who reported sleeping 7.5 to 8.5 hours per night. The opposite was found in a case-crossover study of injured patients; better sleep quality was associated with a lower risk of injury, while increased sleep prior to an injury was associated with an increased risk of injury (Edmonds and Vinson, 2007). These results must be interpreted carefully, as results from case-crossover studies may be subject to potential confounding (Redelmeier and Tibshirani, 1997).

Sleep quantity has been discussed as a risk factor for injury in many occupations. In a case-crossover study of occupational traumatic hand injury, sleep duration was noted

as a risk factor, both for workers who slept five hours or less per night (OR = 1.6; 95% CI = 0.9, 2.8), and for workers reporting nine or more hours of sleep (OR = 3.5; 95% CI = 2.1, 5.9) compared with workers who reported sleeping six to eight hours per night (Lombardi *et al.*, 2004). Six or fewer hours of sleep increased the risk of work-related injuries among veterinarians in Minnesota by 80% (Gabel and Gerberich, 2002).

Shift workers are a growing percentage of the economic work force. Hospitals, industry, and retail stores all are contributing to an increased number of workers on a rotating schedule. Shift workers are believed to be chronically deprived of sleep, regular meal times, and other elements essential to the circadian clock (Richardson *et al.*, 1989). Among nurses who worked non-day/evening shifts, the risk of injury while driving to or from work increased by a factor of two (Gold *et al.*, 1992). Industrial workers at a large engineering company found that the risk of sustaining an injury was 23% greater among those working the night shift compared with the day shift employees (Smith *et al.*, 1994).

Sleep, Injury, and Adolescents

As previously described, factors influencing sleep patterns among adolescents include biological, behavioral, and social parameters. These parameters also may play a role in risk of injury. Among younger children, several studies reported that those individuals who did not get enough sleep sustained a higher number of medically attended injuries (Koulouglioti *et al.*, 2008; Valent *et al.*, 2001).

Among adolescents living on farms in Colorado, sleep patterns associated with increased risk of injury included oversleeping, falling asleep in afternoon class, staying up past 3:00 am, and sleeping less than an average of 8.5 hours per night (Stallones *et al.*,

2006). Decreased sleep as a risk factor for injury also was assessed among high school students in China by Lam and Yang (2007). Adolescents who slept less than seven hours per night during a normal school week were two times more likely to have experienced multiple episodes of unintentional injury than those who slept seven hours or more (OR = 2.2; 95% CI = 1.1, 4.8).

Limitations of Current Research on Adolescent Sleep Patterns and Injury Events

In general, research related to sleepiness and sleep deprivation in adults shows a weak association with injury. Although the studies on adolescents appear to have a stronger association, there still are many questions about the role of sleep as a risk factor for injury among young adults.

Further study is needed to understand the role of sleep and its association with injury among adolescents. Additionally, further insight into different time-consuming activities that may impact the lives of teens is required to help support the health and safety of this vulnerable population.

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Table 1: Summary of literature pertinent to reduced sleep and health consequences (Adapted from Garrard, 2004)

Authors	Year	Purpose	Population	Methods	Findings
Cohen S, Doyle WJ, Alper CM, Janicki- Deverts D, Turner RB	2009	To examine the effects of sleep duration and sleep efficiency on the occurrence on the common cold	78 men and 75 women (age range 21-55 years) who responded to ads, and were judged to be healthy	Logistic regression used to predict colds; multiple linear regression used to predict continuous markers of illness and symptom scores Controlled for: BMI, race, income, education, gender, season of exposure, psychological variables previously associated with risk for colds, smoking, alcohol consumption, exercise	There was a graded association with average sleep duration: participants with less than 7 hours of sleep were 2.94 times (95% confidence interval [CI], 1.18-7.30) more likely to develop a cold than those with 8 hours or more of sleep. The association with sleep efficiency was also graded: participants with less than 92% efficiency were 5.50 times (95% CI, 2.08-14.48) more likely to develop a cold than those with 98% or more efficiency. These relationships could not be explained by differences in prechallenge virus-specific antibody titers, demographics, season of the year, body mass, socioeconomic status, psychological variables, or health practices. The percentage of days feeling rested was not associated with colds.
Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM,	2007	To assess the relationship between diabetes incidence and short sleep	NHANES I data were used: a probability sample of civilian noninstitutionalized	Multivariate longitudinal analysis using logistic regression models.	Subjects with five hours of sleep or less (OR= 1.47, 95% CI: 1.03, 2.09), or nine hours of more sleep (OR = 1.52, 95% CI: 1.06, 2.18) were significantly more likely to have incident diabetes. Short

Authors	Year	Purpose	Population	Methods	Findings
Kreier F, Pickering TG, Rundle AG, Zammit GK, Malaspina D		duration	population of the US between 1971-1975. N = 8,992 subjects between 32-86 years; 430 subjects with incident cases of diabetes	Obesity and hypertension were hypothesized as partial mediators. Other risk factors included depression, alcohol use, gender, age, BMI, physical activity, race and education level.	sleep duration could be a significant risk factor for diabetes, while long sleep duration and diabetes incidence is more likely due to an unmeasured confounder (diabetes causes fatigue, poor sleep quality).
Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, Rundle AG, Zammit GK, Malaspina D	2006	To assess whether short sleep duration would increase the risk for hypertension incidence	NHANES I data were used: a probability sample of civilian noninstitutionalized population of the US between 1971-1975 Self-reported sleep duration from 1982-1984 survey, and hypertension incidence from an 8-10 yr. period until 1992	Cox proportional hazards model included daytime sleepiness, depression, alcohol, salt intake/day, smoking status pulse rate, gender, BMI and history of diabetes	Sleep durations five hours of sleep or less were associated with a significantly increased risk of hypertension (HR =2.10: 95% CI = 1.58, 2.79) in subjects 32-59 years of age. The effect of short sleep duration on hypertension incidence is likely partially related to the influence of short sleep duration on body weight.

Authors	Year	Purpose	Population	Methods	Findings
			Final sample size = 4810 persons		
Mallon L, Broman JE, Hetta J	2005	To investigate the possible relationship among sleep complaints, sleep duration, and the development of diabetes prospectively over a 12-year period in a middle-aged Swedish population.	A random sample of 1,187 subjects, aged 45–65 years, living in mid-Sweden	Multiple logistic regression models, controlling for age, marital status, living alone, hypertension, obesity (BMI >30), smoking, alcohol use, snoring, and depression	<p>The relative risk (95% CI) for development of diabetes was higher in men with short sleep duration (2.8 [1.1–7.3]) or difficulties in maintaining sleep (4.8 [1.9–12.5]).</p> <p>Difficulties in maintaining sleep or short sleep duration (<5 h) were associated with an increased incidence of diabetes in men.</p> <p>Short or long sleep duration or sleep complaints did not influence the risk of new diabetes in women.</p> <p>Men reporting new diabetes diagnoses at follow-up more often reported short sleep duration (<5 h per night) (16.0 vs. 5.9%, $P = 0.01$), difficulties initiating sleep (16.0 vs. 3.1%, $P = 0.001$), and difficulties maintaining sleep (28.0 vs. 6.3%, $P = 0.001$) at baseline than men who did not develop diabetes.</p> <p>Women reporting new diabetes at follow-up reported long sleep duration (>9 h per night) more often at baseline</p>

Authors	Year	Purpose	Population	Methods	Findings
					than women not developing diabetes (7.9 vs. 2.4%, $P = 0.05$).
Ayas NT, White DP, Al-Delaimy WK, Manson JE, Stampfer MJ, Speizer FE, Patel S, Hu FB	2003	To assess if habitually short sleep duration increased the risk of developing diabetes	Nurse's Health Study (70,026 women enrolled, 1,969 diabetic cases)	Multivariate analysis using pooled logistic regression Variables included: age, smoking status, hypertension, alcohol consumption, physical activity, menopausal status, depression, family history of diabetes, history of hypercholesterolemia, shift work, snoring. BMI included in secondary analysis	Compared with women sleeping 8 hours per night, a modest but significant positive association between self-reported sleep duration and incident diagnosis of diabetes, was identified. Both short and long self-reported sleep durations were associated with an increased risk of developing diabetes. For short sleepers, after controlling for body mass index (BMI), the relative risk was attenuated and no longer significant, reflecting a confounding effect of BMI. In long sleepers, a modest but significant positive association between sleep duration and diabetes persisted even after controlling for BMI.
Ayas NT, White DP, Manson JE, Stampfer MJ, Speizer FE, Malhotra A, Hu FB	2003	To determine whether decreased sleep duration is associated with an increased risk of coronary heart disease (CHD) events in women	71,617 female health professionals (ages 45-65 years); 934 coronary events documented during 10 years of follow-up	Multivariate analysis using pooled logistic regression Variables included: age, smoking status, hypertension, alcohol consumption, physical activity, menopausal status,	Age-adjusted relative risks (95% confidence intervals) of CHD (with 8 hours of daily sleep being considered the reference group); relative risks for individuals reporting 5 or fewer, 6, and 7 hours of sleep were 1.82 (1.34-2.41), 1.30 (1.08-1.57), and 1.06 (0.89-1.26), respectively. The relative risk (95% confidence interval) for 9 or more hours of sleep was 1.57 (1.18-2.11).

Authors	Year	Purpose	Population	Methods	Findings
				depression, family history of diabetes, history of hypercholesterolemia, shift work, and snoring. BMI included in secondary analysis	The relative risks of CHD (95% confidence intervals) for individuals reporting 5 or fewer, 6, and 7 hours of sleep were 1.45 (1.10-1.92), 1.18 (0.98-1.42), and 1.09 (0.91-1.30), respectively. The relative risk (95% confidence interval) for 9 or more hours of sleep was 1.38 (1.03-1.86).
Russo M, Thomas M, Thorne D, Sing H, Redmond D, Rowland L, Johnson D, Hall S, Krichmar J, Balkin T	2003	To evaluate the usefulness of oculomotor measurement in quantifying neuronal systems, specifically identifying excessive sleepiness in individuals to determine if they were fit for duty	66 commercial drivers, age 24-62 years; 50 men and 16 women	Sleepiness assessed through Stanford sleepiness scale (SSS); Speed of eye movement measured, and driving performance assessed on driving simulator Regression analyses, repeated measures ANOVA	Groups sleeping 3-5 hours/night had decrease in eye speed movement (saccadic velocity) compared with control group sleeping 9 hours/night, suggesting a slowing of neural responsiveness and metabolic deactivation
Belenky G, Wesensten NJ, Thorne DR, Thomas ML, Sing HC, Redmond DP,	2003	To determine the effects of several levels of restricted sleep over 7 days on alertness and	66 commercial drivers, ages 24-62 years; 50 men and 16 women	Psychomotor vigilance tasks (PVT) measures reaction time to visual stimulus	Seven days of sleep restriction degraded psychomotor vigilance performance in a sleep-dose-dependent manner. With mild to moderate sleep restriction (7- and 5-hours Time In Bed),

Authors	Year	Purpose	Population	Methods	Findings
Russo MB, Balkin TJ.		objective performance and to determine the extent to which 3 days of recovery sleep restored performance		ANOVA with repeated measures	<p>performance initially declined and, after a few days, appeared to stabilize at a lower-than-baseline level for the remainder of the sleep restriction period. In contrast, with severe sleep restriction (3-hours Time In Bed), performance declined continuously across the sleep restriction period, with no apparent stabilization of performance.</p> <p>Based on these findings, it appears that the inflection point (i.e., the minimum amount of nightly sleep required to achieve a state of equilibrium in which daytime alertness and performance can be maintained at a stable, albeit reduced, level) is approximately 4 hours per night.</p>
Spiegel K, Sheridan JF, Van Cauter E	2002	To examine the effect of sleep deprivation on immune response to influenza vaccination	25 men (mean age 23 years old); none of subjects had influenza immunization in past 3 years	<p>11 men had sleep restriction to 4 hours/night</p> <p>Blood sample taken immediately after immunization, 10 days later; antibody titers measured in blood sample</p>	Ten days after vaccination, mean (SD) antibody titers in subjects who were immunized in a state of sleep debt, were less than half those measured in the subjects with normal sleep times
Girardin JL, Kripke DF,	2000	To investigate if self-reported	263 San Diego adults (144 women,	Main effects analysis of covariance	Volunteers slept an average of 6.22 hours/night (current definition of

Authors	Year	Purpose	Population	Methods	Findings
Ancoli-Israel S, Klauber MR, Sepulveda RS.		sleep duration is in decline and to focus on gender and ethnicity effects on sleep	129 men), recruited by random telephone calls; 77% non-hispanic white, 78% with office jobs; Illumination and sleep monitored by wrist bands	Covariates: gender, ethnicity, age, time reference, and work status	<p>insomnia emphasizes sleep durations of less than 6.5 hours).</p> <p>Women generally slept more than men, and had better sleep amplitude, but this trend was not significant when work status entered into model.</p> <p>White volunteers slept more than Hispanic volunteers.</p>
Dement, WC	1999	To give a comprehensive overview of the different aspects of sleep medicine	Pioneer researcher outlined personal research, as well as most of the main research topics and results	<p>Chapter topics include:</p> <ol style="list-style-type: none"> 1. The fundamentals of sleep 2. When sleep fails 3. When sleep works 4. The principles of healthy sleep 	The United States is a sleep-starved society.

TABLE 2: Summary of literature pertinent to adolescent sleep patterns and habits (Adapted from Garrard, 2004)

Authors	Year	Purpose	Population	Methods	Findings
Fischer F, Nagai R and Teixeira LR.	2008	To identify factors related to sleep duration among high school students	92 high school students attending evening classes in Sao Paulo, Brazil	Cross-sectional questionnaire and use of multiple linear regression analyses Work, sex, age, smoking, alcohol and caffeine consumption, and physical exercise were controlled for in the analyses.	Students who worked and attended school had decreased sleep duration during the weekdays, with a sleep rebound on the weekend.
Ghanizadeh A, Kianpoor M, Rezaei M <i>et al.</i>	2008	To analyze sleep patterns, habits of Iranian high school-aged children	1420 high school students from Shiraz, Iran; age range 15-18 years	Cross-sectional survey; self-reported information; descriptive statistics	Sleep patterns in Iran are more like patterns in USA than Asia; mean duration of sleep = 7.7 hours, and time of going to bed increased with grade level and gender (boys later than girls).
Steptoe A, Peacey V, Wardle J	2006	To assess the relationship between sleep duration and self-rated health in young adults.	17,465 university students aged 17-30 years at 27 universities in 24 countries	Self-reported sleep duration and health Covariates included: age, sex, socioeconomic background, smoking, alcohol consumption, BMI,	Compared with referent category (7-8 hours/night), respondents sleeping 6-7 hours/night had an adjusted odds ratio of poor health of 1.56 (95% CI = 1.22-1.99), < 6 hours/night OR = 1.99 (95% CI = 1.31, 3.03). The same significant pattern was seen when the results were analyzed separately

Authors	Year	Purpose	Population	Methods	Findings
				physical activity, depression, recent use of health services, country of origin	by sex. When respondents from Japan, Korea, and Thailand (characterized by relatively short sleep durations) were excluded, the adjusted odds ratios were 1.33 (95% CI = 1.03-1.73) and 1.62 (95% CI= 1.06-2.48) for those sleeping 6 to 7 hours and less than 6 hours, respectively. There were no significant associations between self-rated health and long sleep duration.
LeBourgeois MK, Giannotti F, Cortesi F, Wolfson AR, and Harsh J	2005	To examine the relationship between self-reported sleep quality and sleep hygiene in Italian and American adolescents, and to assess the role of sleep hygiene in sleep patterns	776 Italian and 572 American adolescents sampled from public high schools in Rome, Italy and Hattiesburg, Mississippi	Self-reported questionnaires included Adolescent Sleep-Wake Scale; Sleep Hygiene Scale; Pubertal Development Scale (Tanner scale); Morningness/Eveningness scale	Sleep quality is multi-dimensional and requires both good internal factors (biological, maturational health, and psychosocial factors) and external factors (family, environment, culture). Sleep hygiene is a good predictor of sleep quality in American and Italian adolescents. Factors associated with good sleep hygiene included: a regular sleep-wake cycle; suitable sleeping environment; and a good bedtime routine to prepare the adolescent for sleep.
Hasler G, Buysse DJ, Klaghofer R, Gamma A, Ajdaciv V, Eich D, Rossler W,	2004	To assess the association between short sleep duration and obesity and weight gain in young adults.	496 young adults, interviewed 4 times at ages 27, 29, 34 and 40 years from the Zurich Cohort, Zurich	Cohort study using interviews for psychiatric, medical conditions, and health habits (SPIKE interview). Short sleep	Strong association between short sleep duration and obesity (OR = 7.4; 95% CI = 1.3, 43.1)

Authors	Year	Purpose	Population	Methods	Findings
Angst J			Switzerland; first interviews in 1988	durations defined at less than 6 hours per night, BMI set at greater than 30; Generalized Estimating Equations used for analysis; controlled for physical activity, demographics, family history of obesity	
Dahl RE, Lewin, DS	2002	Excellent overview of sleep regulation and behavior in adolescents	varies	varies	From Carskadon, 1990: Puberty itself imposes a burden of increased daytime sleepiness with no change in nocturnal sleep. Part-time employment has a significant impact on the sleep patterns of teenagers: those who work more than 20 hours each week sleep less, go to bed later, are sleepier, and drink more caffeine and alcohol. Development of circadian rhythms may also play a role in the phase delay teenagers commonly experience. The consequences of the chronic pattern of insufficient sleep are daytime sleepiness, vulnerability to catastrophic injuries, mood and behavior problems, increased vulnerability to drugs and

Authors	Year	Purpose	Population	Methods	Findings
					<p>alcohol, and development of major disorders of the sleep/wake cycle. From Carskadon MA 1990 (alcohol drugs driving), it was noted that there is an additive impact of alcohol and sleep deprivation on cognitive abilities and motor coordination.</p> <p>From Dahl, RE: Attention Deficit Hyperactive Disorder-like symptoms were found to be associated with sleep deprivation.</p>
Thorleifsdottir B, Björnsson, <i>et al.</i>	2002	To examine sleep habits and how they develop in young people	668 subjects (age 1-20 years) who responded to postal surveys	Cross-sectional with longitudinal component	<p>Lengthening of sleep on weekends was first significant at age 9, and greatest among adolescents. The incidence of daytime sleepiness increased with adolescence, as did napping with decrease in nocturnal sleep time.</p> <p>Icelandic adolescents have delayed bedtimes and shorter nocturnal sleep than Europeans.</p>
Giannotti F, Cortesi F, Sebastiani T and Ottaviano S	2002	To determine the relationship between circadian preferences, sleep patterns, sleep problems and daytime sleepiness and	6,631 Italian high school students (age 14-18); analysis on Morning (M-types, N = 1005) and Evening (E-types, N = 742)	<i>School Sleep Habits Survey</i> , a cross-sectional questionnaire, with multiple regression analysis and logistic regression analysis	<p>E-types: average deficit of 2 hours sleep/week compared with M-types (30 minutes).</p> <p>E-types more frequently reported napping during school days, daytime sleepiness, attention problems, poor school achievement, more injuries, greater</p>

Authors	Year	Purpose	Population	Methods	Findings
		behaviors.			emotional problems, and an increased use of caffeine and sleeping aids.
Fukuda K and Ishihara K	2001	To investigate the sleep pattern and mental health of adolescents	10,000+ students (age12-18) and 700 university students	Cross-sectional questionnaire administered through teachers	Time to sleep delayed linearly throughout adolescence; nocturnal sleep time decreased. Daytime sleepiness peaked at high school age.
Saarenpaa-Heikkila O, Laippala P and Koivikko M	2000	To assess the predictors associated with subjective daytime sleepiness in schoolchildren	214 children (age range 12-20years)	2-phase study with 2-year interval between questionnaires; chi-square analysis used	Daytime sleepiness is most common in late puberty. The stress of schoolwork can cause daytime sleepiness in children; persistence of daytime sleepiness was brought on by night wakings (poor sleep quality).
Spiegel K, Leproult R Van Cauter E	1999	To investigate the impact of sleep debt on metabolic and endocrine function	11 healthy young men, age 18-27 years, who participated in a 16 night sleep center study and had sleep curtailed to 4 hours/night	Repeated measures ANOVA used to compare the sleep-debt condition with measurements taken at the end of a sleep-recovery period when participants were allowed 12 hours in bed per night; included glucose tolerance test	Glucose tolerance was lower in the sleep-debt participants than in the fully-rested participants. Sleep debt has a harmful impact on carbohydrate metabolism and endocrine function. The effects are similar to those seen in normal ageing and, therefore, sleep debt may increase the severity of age-related chronic disorders.
Wolfson AR,	1998	To describe the	3,120 high	Cross-sectional	Students, who described themselves as

Authors	Year	Purpose	Population	Methods	Findings
Carskadon MA		relation between adolescents' sleep/wake habits, characteristics of students (age, sex, school), and daytime functioning (mood, school performance, behavior)	schools students from 4 public high schools in Rhode Island	survey (Sleep Habits Survey) Multivariate analysis of variance	struggling/failing in school, reported that on school nights they obtained 25 minutes less sleep and went to bed on average 40 minutes later than A/B students. Students who slept < 6hours, 45minutes, or who stayed up later on weekend nights reported increased daytime sleepiness, depressive mood, and sleep/wake behavior problems compared with students who averaged 8hours,15minutes, with less sleep delay on weekends.
Dinges DF, Pack F, Williams K, Gillen KA, Powell JW, Ott GE, Aptowicz C, Pack AI	1997	To determine whether cumulative sleep debt resulted in changes in mood disturbance and psychomotor performances	16 healthy young adults (mean age 22)	Nightly sleep limited for 1 week in a sleep lab; performance and mood tests performed 3 times/day; ANOVAs assessed variance across days and within days	Sleep restriction increased sleepiness, and all mood states. Psychomotor task performance showed shift after the 2 nd day of sleep restriction. Recovery from effects of sleep restriction for 7 days required obtaining 2 nights of recovery sleep.

Table 3: Summary of literature pertinent to reduced sleep and work-related injuries (Adapted from Garrard, 2004)

Authors	Year	Purpose	Population	Methods	Findings
Philip P and Akerstedt T	2006	Review of literature on occupational driving and safety	Review of literature	Review of literature	Impaired or shortened sleep is a major cause of injury events in industry and transport.
Lombardi DA, Sorock GS, Folkard S, Hauser RB, Eisen EA, Herrick R, Mittleman MA	2004	To evaluate the association between self-reported sleep duration on the night before an injury	1166 workers from 23 occupational health clinics in New England	Case-crossover design	Compared to an average night sleep duration (6-8 hours), there was an increased risk for workers with 5 or less hours of sleep on the night before an injury, or 9 or more hours of sleep.
Connor J, Whitlock G, Norton R Jackson R	2001	To assess the available evidence for a causal role of driver sleepiness in car crash injury	Review of literature; all observational studies	Review of literature	The direct epidemiologic evidence for a causal role of fatigue in car crashes is weak, but suggestive.
Frank, AL	2000	To review the relationship of shiftwork to industrial injuries	Observational studies, mostly retrospective	Review of literature	Shiftwork should be avoided, but if necessary, certain patterns and rest breaks appear to be associated with fewer injuries.
Hakkanen H and Summala H	2000	To examine the frequency of driver sleepiness-related problems at work during	184 long-haul drivers and 133 short-haul truck drivers in	Questionnaire filled out voluntarily by truck drivers at a	About 40% of the long-haul drivers and 21% of the short-haul drivers

		the previous three months and to assess the incidence of sleep apnea syndrome symptoms	Finland	large Finnish trucking company	reported having problems in staying alert on at least 20% of their drives. Over 20% of the long-haul drivers also reported having dozed off at least twice while driving. Near misses due to dozing off had occurred in 17% of these drivers.
Lyznicki JM, Doege TC, Davis RM, Williams MA	1998	To assess the contribution of driver sleepiness to highway crashes	Information from MEDLINE, TRIS (Transportation Research Information Service) and BEDS (Bibliographic Electronic Databases of Sleep), 1975-1997	Review of Literature	Driver sleepiness is a causative factor in 1% to 3% of all US motor vehicle crashes. Surveys of the prevalence of sleepy behavior in drivers suggested that sleepiness may be a more common cause of highway crashes than is reflected in these estimates. About 96% of sleep-related crashes involve passenger vehicle drivers and 3% involve drivers of large trucks. Risk factors

					include youth, shift work, alcohol and other drug use, over-the-counter and prescription medications, and sleep disorders.
Mitler MM, Carskadon MA, Czeisler CA, Dement WC, Dinges DF, Graeber RC	1988	To report on committee consensus from the 1986 annual meeting of the Association of Professional Sleep Societies (Columbus OH, June 15-22, 1986)	Catastrophic events	Committee evaluated scientific and technical reports on the occurrence of medical and human error catastrophes	Sleep and sleep-related factors appeared to be involved in widely disparate types of disasters.

Table 4: Summary of literature pertinent to reduced sleep and injuries (Adapted from Garrard, 2004)

Authors	Year	Purpose	Population	Methods	Findings
Koulouglioti C, Cole R, Kitzman H	2008	To explore the relationship between adequacy of sleep and injuries sustained by children (1-4 years old)	278 mothers and their preschool children, recruited from 4 pediatric practices	Descriptive, longitudinal study; analysis using poisson regression, controlling for maternal age, education and child's temperament	Children who did not get enough sleep sustained a higher number of medically-attended injuries.
Lam, LT and Yang L.	2007	To investigate the association between nightly sleep duration and unintentional injuries among high school students in Nanning, China	Total adolescent population (age 13-17) of Nanning (approximately 60,000 individuals) attending first 3 years of high school	Population-based, cross-sectional survey; Logistic regression analysis, adjusting for: sex, father's education level, family income, physical activity, snoring; Self-reported sleep information, structured interview on injury events	Adolescents, who slept less than 7hours/night, during a normal school week, were two times more likely to have experienced multiple episodes of unintentional injury than those who slept 7 hours or more. (OR =2.2, 95% CI = 1.1, 4.8); 70% Increased risk of multiple injuries among males in adjusted analysis, 30% increase for a single injury.
Edmonds JN and Vinson DC	2007	To analyze case-control and case-crossover data	2517 injured individuals (1085	Controls matched on time and person.	Better sleep quality in the past seven days was

Authors	Year	Purpose	Population	Methods	Findings
		about sleepiness, usual sleep, recent hours of sleep among patients presenting with injuries in a medical facility	men, 1432 women) who presented at one of three emergency departments in Boone County, Missouri; Control group recruited through random-digit dialing.	Conditional logistic regression analysis, matching on age, sex, rural vs. urban, day and time; Subgroup analysis done on traffic-related injuries	associated with a lower risk of injury (OR = 0.88; 95% CI = 0.8, 0.97).
Choi SW, Peek-Asa C, Sprince NL, Rautiainen RH, Flamme GA, Whitten PS, Zwerling C	2006	To assess the association between sleep disturbance and injuries in a rural population.	1345 adults enrolled in the Keokuk County Rural Health Study; data collected from March 1999, April 2005. 20-year prospective cohort study focusing on chronic disease and injury in a rural community	Sleep quality assessed by snoring frequency, snoring severity, daytime sleepiness; sleep quantity by reported hours of sleep; Multivariate poisson regression analysis adjusted for age, sex, general health, alcohol use, depression status	With regard to sleep quantity, sleeping for less than 7.5 hours per night increased risk of injury by 61% (RR = 1.61; 95% CI =1.2, 2.2), compared with people sleeping between 7.5 and 8.5 hours/night.
Stallones L, Beseler C, Chen P	2006	To describe the relationship between sleep patterns and injury occurrence among adolescents (age13-18) living on farms in Colorado	262 farm youth randomly selected from 18 counties in Colorado	Cross-sectional survey; Logistic regression analysis, controlled for gender, age	Sleep patterns associated with increased risk of injury included oversleeping, falling asleep in afternoon class, ever being up past 3 am, sleeping less than an average of 8.5

Authors	Year	Purpose	Population	Methods	Findings
					hours/night on weekends, on school nights and weekends combined.
O'Brien EM, and Mindell JA	2005	To examine the relationship between adolescent sleep-wake patterns and risk-taking behaviors	388 high school students (217 males, 171 females), grades 9-12, ages 14-19, from 4 high schools in Philadelphia		Risk-taking behaviors increased in upper grades compared with lower grades. Students who reported sleep habits resulting in insufficient sleep also reported engaging in increased risk-taking behaviors compared with students who reported obtaining more adequate sleep.
Valent F, Brusaferrero S, Barbone F.	2002	To evaluate the association between sleep and wakefulness duration and childhood injury events	292 injured children who presented at a Children's Emergency Center in Udine Italy	Case-crossover design; Logistic regression analyses, stratified by gender, age	An association between sleeping less than ten hours/night and injury risk was found among boys (RR = 2.33; 95%CI: 1.07, 5.09), but not for girls.
Terán-Santos J, Jiménez-Gómez A, Cordero-Guevara J	1999	To study the relationship between sleep apnea and traffic crashes	102 drivers who received treatment at hospitals in Burgos or Santander Spain between April and	Case-control study: Controls matched on age and sex; Analysis adjusted for confounders of	Compared with individuals without sleep apnea, patients with high apnea index were 6 times more likely

Authors	Year	Purpose	Population	Methods	Findings
			December 1995; Controls were 152 patients randomly selected from primary care centers in same cities	alcohol use, visual-refraction disorders, BMI, years of driving, history of traffic events, use of medications and sleep schedule	to be involved in a traffic crash than individuals without sleep apnea (OR =6.3; 95% CI: 2.4, 16.2). After adjustment, OR increased to 7.2 (2.4, 21.8).
Lyznicki JM, Doege TC, Davis RM, Williams MA	1998	To assess the contribution of driver sleepiness to highway crashes	Information from MEDLINE, TRIS (Transportation Research Information Service) and BEDS (Bibliographic Electronic Databases of Sleep), 1975-1997	Review of Literature	Driver sleepiness is a causative factor in 1% to 3% of all US motor vehicle crashes. Surveys of the prevalence of sleepy behavior in drivers suggested that sleepiness may be a more common cause of highway crashes than is reflected in these estimates. About 96% of sleep-related crashes involved passenger vehicle drivers and 3% involved drivers of large trucks. Risk factors included youth, shift work, alcohol and other drug use, over-the-counter

Authors	Year	Purpose	Population	Methods	Findings
					and prescription medications, and sleep disorders.
Acebo C, Wolfson AR, Carskadon MA	1997	To assess the relationship among adolescent sleep-wake patterns, health indicators, and injury reports	3119 high school students from 3 Rhode Island school districts administered Sleep Habits Survey, and asked about self-reported injury events during previous six months	Cross-sectional survey	Teens with low amounts or irregular sleep timing were more likely to report decreased school attendance and increased injuries.

CHAPTER III

RESEARCH DESIGN AND METHODS

Specific Aims

This research examines the effects of sleep on the risk of injury among rural adolescents. The specific aims were to: (1) Identify associations between different sleep patterns of rural adolescents and their risk of injury, and (2) Determine whether sleep quantity among working adolescents impacts risk of injury, especially in the diverse occupational environments to which they are exposed.

Overview

The study, herein, is based on data collected for the Childhood Agricultural Trauma Evaluation System (CATES) study (Williams *et al.*, 2006), a four-year NIOSH-sponsored surveillance study of work patterns and all injury experience among adolescents attending public high schools in rural Minnesota.

For the CATES (Williams *et al.*, 2006) study, a model was developed for conducting statewide surveillance of work and injury among rural Minnesota youth in public high schools. A cluster sample of schools from four distinct agricultural regions was drawn and recruited for participation in the study. This epidemiologic study examined a population of public high school students in rural schools with class sizes greater than 25 individuals. Recruited schools were required to identify an agent to complete all steps of a Federal Wide Assurance agreement, as outlined by the Office of Human Research Protection. Through this collaboration, the Minnesota Department of

Health (MDH) was allowed to obtain student rosters from each participating school. Each student, registered at the participating schools, as of August 15, 2001, was given a unique identification number; in turn, a matched set of questionnaire instruments was provided to the pertinent teacher/liaison at the respective school, for the two-year data collection cycle.

Students received the first questionnaire instrument in the autumn months of 2001. Questions addressed demographics, work experience and injury events during the previous three summer months of June, July and August 2001. The next questionnaire was administered the following spring and included the same question topics of demographics, work experience and injury events regarding the 2001-2002 school year of September through May. Subsequent questionnaires were administered at equivalent time periods during the next school year, asking questions about events occurring during the summer months of 2002 and the school year of 2002-2003. All activities met the approval of the Institutional Review Board of the Minnesota Department of Health. Additional analyses also were approved by the University of Minnesota Institutional Review Board.

For this study, *rural* included all non-metropolitan counties as defined by the United States Department of Agriculture Urban-Rural Continuum Codes for Metropolitan and Non-Metropolitan Counties. The definition for *work* was: “Paid or unpaid employment either at or away from your home; chores or work done for your family, such as lawn care, babysitting, dishes; chores or work done outside of your home; and/or seasonal activities such as working harvest or life-guarding.” *Injury* was defined as: “any event that restricted your normal activities for at least four hours; and/or resulted in a loss

of consciousness, loss of awareness or amnesia for any length of time; and/or caused you to seek professional health care, including care by doctors, nurses, chiropractors, dentists or other healthcare professionals.” Sleep characteristics were collected through several questions on typical sleep habits over the course of the questionnaire time period; the main focus of these queries was quantity of sleep, both during the weeknights of Sunday through Thursday and the weekend nights of Friday and Saturday, an additional question, which focused more on sleep quality, asked about the typical time that individuals went to sleep at night.

All four questionnaires were completed by a total of 5,922 unique students with individual questionnaire identification numbers. Data collection was completed in June 2003; cleaning, coding, and analysis activities were completed in December 2005.

CATES Target Population

The target population for this study included all public high school students in rural Minnesota who attended schools with overall grade sizes greater than 25 students. The goal was to obtain a sample that would reflect the true incidence of injury among the largest population of adolescents in Minnesota – that is, those attending typical schools and being involved in the typical activities of young adults in non-urban communities.

Sample Selection: County and School Selection

To calculate agricultural injury rates among public high school students, grades 9 through 12, in Minnesota’s rural communities, three pieces of information were required: (1) a classification system to define a county as rural; (2) the distribution of agricultural operations in Minnesota by the major agricultural products; and (3) the number and

location of eligible schools within these rural agricultural communities and their student enrollments.

Minnesota's rural communities were defined by utilizing the United States Department of Agriculture's (USDA) Urban-Rural Continuum Codes for Metropolitan and Non-Metropolitan Counties. These codes were developed by the USDA to categorize counties by population size and proximity to metropolitan areas. The definitions of codes identified by the USDA are summarized in **Table 1**.

Using these codes, 70 of the 87 Minnesota counties are defined as non-metropolitan (Butler and Beal, 1994). Three additional counties were excluded from the CATES sampling frame because of past participation in MDH activities; this accounted for a total of 67 participating non-metropolitan counties in Minnesota (Williams *et al.*, 2006).

Because agricultural hazards vary, based on the type of enterprise (e.g., dairy, beef, grain), information from the Minnesota Department of Agriculture was used to identify the top ten counties producing each of Minnesota's major agricultural products. These counties were then mapped into four different agricultural regions: (1) swine, corn, and soybeans; (2) dairy and poultry; (3) forestry and wild rice; and (4) small grains, such as wheat and sugar beets (see **Figure 1** map). Schools were sampled from each region to ensure representation from the diverse base of agriculture production in Minnesota.

Within the 67 rural counties, there were 220 public schools that convened high school classes during the 1999-2000 school year. **Table 2** shows the characteristics for public schools in each of the four agricultural regions included in the study sampling frame. School estimates were derived from a database maintained by the Minnesota

Department of Children, Families and Learning (now Minnesota Department of Education).

A list of all public schools was obtained from the Minnesota Department of Education. The sample of schools for recruitment was drawn from this list and included all schools that had a high school population of 9th, 10th, 11th, and 12th grades and were located in one of the 67 rural counties, as defined earlier.

Sample Size Determination:

The goal of this sampling strategy was to select students in a manner to ensure they would represent the true incidence of injury among all public high schools in Minnesota's rural communities. There were several key factors in this sampling strategy, including the agricultural regions, the number of schools and their distribution in each region, and the number of students within each school. To ensure that the sample reflected the population, with respect to agricultural region, proportional allocation (where the number of schools sampled in each stratum is proportional to the total number of schools in each of the stratum), was utilized.

To calculate the sample size requirements (e.g., schools needed in each region), an agricultural activity-related injury incidence rate, per 100,000 hours worked on an operation, was used. The expected incidence injury rate may range between 10 to 76/100,000 hours worked for adolescents working in the agricultural industry (Lexau *et al.*, 1994; Parker *et al.*, 1994; Gerberich *et al.*, 1993). Also, the average number of hours worked ranged from 16-30 hours per week, depending on the time of year. An average annual value of 20 hours/week was used to establish a reasonable basis for the calculations. It was assumed that the agricultural injury incidence rate of 17/100,000

hours worked was a reasonable, yet conservative, estimate and that a sample size was required to ensure precision adequate to estimate the overall state incidence rate to within 10 percent (relative error). Injuries related to non-agricultural work activities, and other activities such as recreational sports or school-related activities were believed to be more frequent than agricultural injury; thus, this sample size was estimated to be sufficient to estimate those injury incidence rates also.

Estimates of the size of the grades, 9 through 12 in the eligible schools were obtained from the Department of Education. Since grade size varied markedly within regions, schools were sampled to obtain a probability-weighted sample from each group defined by grade size. These weights were the reciprocal of the grade size to ensure that each child had equal probability of being selected, and that no bias resulted due to different school and grade sizes. Thus, schools with large grade sizes had a smaller weight assigned per student than schools with smaller grade sizes.

Sampling Methods:

It was decided to combine the sampling for CATES (Williams *et al.*, 2006) and the Childhood Agricultural Safety and Health (CASH) (Williams *et al.*, 2004) an initiative that was granted at the same time to the MDH. This decision was made not only for budgetary reasons, but also because it would be difficult to find sufficient schools for both studies, separately. Within the agricultural regions, power calculations for the CASH grant indicated that selecting 10 schools per region would be sufficient. These numbers also were adequate for CATES (Williams *et al.*, 2006), with the addition of one more school in the grains and sugar beets agricultural region due to the difference

in grade sizes and number of schools. Schools were sampled in the four different agricultural regions as shown in **Table 3**.

Both studies used a stratified cluster sample strategy, with agricultural regions comprising the strata and schools the clusters. Utilizing this strategy enabled calculations of incidence rates of agricultural injury for each agricultural region as well as for the entire state population of non-metropolitan public high school students. Stratification would be expected to increase precision and enabled a comparison of rates among regions (Cochran, 1977). Cluster sampling, however, tended to decrease the precision of population estimates, since students in the same school would tend to be more similar to each other than students in different schools.

In the first year of the CATES study (Williams *et al.*, 2006), this sample was comprised of students in grades 9 through 11, who completed questionnaires twice during the school year (Fall and Spring). This same group of students was in grades 10 through 12 in the second year of the study, when the questionnaires were again administered in the Fall and Spring. This constituted the longitudinal component of the study. **Figure 2** describes the flow of students throughout the study.

Questionnaire Development:

Questionnaire design began with a literature review of relevant topics to determine current available information associated with potential risk factors related to injury among adolescents. An overall conceptual model for the occurrence of injury events, based on previous knowledge, was developed and is presented in **Figure 3**. This model was based on the epidemiological model of human damage involving the dynamic interactions of a host, agent(s) and vehicles (or vectors) within the environment: the host

is the person injured; the agents of injury are various forms of energy, including mechanical energy which accounts for the majority of physical injury events; and the vehicle refers to any element in the environment that conveys the agents (Gibson, 1961). For example, in the case of injuries among adolescents, the vehicle may involve an animal which may transmit the energy via the use of extremities to kick, or it may involve a sharp knife or cutting implement that facilitates transmission of the energy (Haddon *et al.*, 1964; Robertson, 1984).

Based on the conceptual model, the CATES (Williams *et al.*, 2006) questionnaire was designed to collect information from students on demographic factors, personal factors related to allocation of time, environmental work factors, and asthma occurrence. Household factors were not included in the questionnaire due to the length of the instrument and the sensitive nature of asking such questions. Questionnaire development included efforts from grant consultants as well as two pilot implementations within non-sample schools. The CATES (Williams *et al.*, 2006) questionnaire enabled collection of information from students to facilitate calculation of injury incidence rates and cohort analysis of potential injury risk factors. The Institutional Review Board of the Minnesota Department of Health approved the comprehensive study. In addition, the current sub-study was approved by the University of Minnesota Institutional Review Board.

Contact Procedures and Data Collection

School Recruitment:

All schools eligible for participation in each of the four geographic regions were assigned a random number. Schools were recruited in random order within each region. Because of different student enrollment, ten schools were selected from regions one, two,

and three while 11 schools were selected from region four. The school administration (i.e. principal of the school and/or superintendent of the school district) of each selected school had to be willing to facilitate administration of work-related injury questionnaires in the Fall and Spring of each school year for two years, as well as all activities related to the CASH intervention implementation. The MDH worked extensively with an Advisory Group and the Minnesota School-to-Work program to determine methods to present the study to schools that would reduce barriers and facilitate study participation. Since each school district and each school was unique, a versatile, flexible recruitment strategy was developed to optimize participation. Numerous letters and programmatic information were sent to each selected school, followed by in-person visits from study staff. Each school had an individual designated as a liaison; this person was responsible for questionnaire administration, answering questions from parents or the community, and promoting the study within the school. Schools received some financial support to offset the costs of participation, such as mailings, staff time needed for questionnaire distribution, and administrative activities.

Questionnaire Administration:

The questionnaire was administered twice during both the first and second years of implementation for a total of four data collection points. In the first year, administration of the questionnaire to students in grades 9 through 11 took place during the first four months of the school year to capture information on work and injuries occurring during the Summer months, and once within the last two months of the school year to address work habits and injury patterns occurring during the academic year. During the second year of implementation, the questionnaire was administered to

students in grades 10 through 12 during the same general time periods. Data on individuals followed over time were linked by a designated identification code assigned by the MDH. As described above, a faculty or staff liaison was chosen from each sampled school to help with questionnaire administration.

Administration of the questionnaires was done through several different methods, depending on the school's preference and organization. In small and medium schools, the administration often was completed during class periods that were grade specific (e.g. 9th grade English, 10th grade health, or 11th grade social studies). In most large schools, a school-wide assembly or advisory period was used to administer the questionnaires. In cases of absenteeism, the liaison instructor in many school districts attempted to contact the student and gain participation for up to two weeks from the date that his or her fellow classmates completed the questionnaire.

Questionnaire Processing

Questionnaires were printed on scannable (machine-readable) forms. Scanning protocols and data dictionaries were developed and tested prior to scanning. A sample of questionnaires were double-entered by trained personnel and checked with the scanned data to assure the accuracy of the scanning system prior to the scanning all questionnaires.

After scanning was complete, data were organized through a FoxPro data management system. Further evaluation for consistency of responses, skip patterns, numeric consistency of dates (e.g., age, sex and grade), and general acceptability of answers was completed prior to data analysis. All further analysis used Statistical

Analysis Software (SAS), version 8.2, and SAS version 9.1.3 (SAS Institute, Cary, North Carolina).

Data Analysis

Overview of Data Analysis

The goal of data analysis for this research was to analyze the impact of sleep quantity on the outcome of injury within this population of adolescents attending high school in rural communities. The first aim was to evaluate the potential association among the entire population of young adults, assessing all types of injury, whether a work-related, sports-related, or motor vehicle-related injury event. The referent group for this analysis was all students who slept nine hours or more per night, compared with adolescents who slept less than the recommended nine hours. The second aim was to address a subset of this population, the working students. Work was given a fairly liberal definition in order to capture all chore-related injuries, as farm residents were considered to be exposed to occupational exposures while doing what could be considered everyday chores. Analyses were conducted to determine the effect of sleep on work-related injuries among employed youth.

To accomplish this goal, factors of primary interest, as identified in the conceptual model (**Figure 3**), were examined utilizing multivariate analyses. For each exposure of interest, selection of confounders for the multivariate analyses was based on a directed acyclic graph (DAG), following the methods described by Greenland *et al.* (1999) and illustrated by Hernan *et al.* (2002) (**Figure 4**). These methods not only identified minimal confounder sets leading to parsimonious models, but also identified covariates that should not be entered into the analyses because of potential introduction of bias.

Injuries of interest included those meeting the definition, as presented previously. Potential confounding factors included other known or suspected risk factors, such as age, gender, residence by agricultural area of Minnesota, and hours spent in other activities such as school, recreation and/or work. The ultimate goal of this analysis was to help direct possible prevention or intervention activities to maintain the safety and health of rural adolescents.

Aim 1:

Sleep patterns and risk of injury among rural Minnesota adolescents

(Chapter 4)

It is generally believed that humans need one hour of sleep for every two hours of wakefulness, and a full spectrum of health consequences may result from accumulating sleep debt (Dement, 1999). Adolescence is a time of great developmental change, from a physical, psychological and social perspective (Richardson and Tate, 2002). One aspect of this change is an alteration in sleep patterns. Sleep is regulated by two different systems: the circadian biological clock and a sleep/wake homeostasis (Carskadon, 1993). Young adults appear to undergo a shift in sleep-wake cycles, such that they stay up later in the evening and prefer to sleep later in mornings than do preadolescents (Carskadon, 1993, Fukuda and Ishihara, 2001). This phase delay is believed to be both biological and environmental in nature, since the teen years are a period of increased time constraints due to work, school and social commitments as well as a time of major endocrine alterations (Dornbusch, 2002). The sleep patterns of adolescents have generated significant community concern in recent years, prompting high schools to re-evaluate scheduling and school start times to try to minimize sleepiness during classes

(Carskadon, 2002). While adolescents appear to suffer from increased sleep deprivation, it is unclear how this lack of sleep may impact other aspects of adolescent life, including their health and safety. Sleepiness has been identified as a risk factor in injury events through some studies (Connor *et al.*, 2001; Lyznicki *et al.*, 1998), usually related to driving. Yet, further study is needed to understand the role of sleep and its association with injury among adolescents.

The purpose of this study was to analyze data from the Youth at Work program, a cohort of adolescents attending public high schools throughout the rural counties of Minnesota, to determine whether an association exists between sleep behaviors and injury outcomes.

Univariate analyses were employed first to describe the characteristics of the cohort. Cross-tabulations were used to calculate rate ratios and confidence intervals to examine if individual exposure was a risk factor or potential confounder. Based on the conceptual and causal models for this study, variables were selected to enter the multivariate model analyses.

An overall conceptual model for the occurrence of injury events, based on previous knowledge, was presented in **Figure 3**. This model served as the basis for a causal model and relevant directed acyclic graphs (DAGs). To further investigate the assumptions behind the standard analysis, a DAG was developed and is presented in **Figure 4** to enable selection of potential confounders for each causal contrast of interest and to guide estimation of specific effects (Greenland *et al.*, 1999). This DAG was based on previous published information, deduction from this information and previous knowledge of injury mechanisms; also, considered, were data from prior research and

information provided by the study advisory group, comprised of teachers, school administrators, public health nurses, safety professionals and injury epidemiologists.

Some of the many factors that might increase or decrease injury occurrence among adolescents included age, gender, type and extent of exposure to hazards such as machines or animals, physical ability, risk perception, safety behaviors, level of knowledge, past experience, and drug or alcohol use. All of these factors were included in the conceptual model; however, in describing the role of hours of sleep as it pertains to injury occurrence, the following variables were considered in the DAG and thus, were considered for analysis:

Gender: Males may have an increased risk of injury compared with females (Gerberich *et al.*, 1993; 1997; 2001; 2003; 2004). Gender also may impact the rate of smoking, alcohol use, and the number of hours worked.

Grade: As a measure of age, younger students may have an increased risk of injury compared with older students. Age/grade level also may impact the rate of smoking, alcohol use, and the number of hours worked, and the type of occupation and occupational exposures. In particular, age may impact the quality and quantity of sleep. (Carskadon, 1990; 2002; 2004, Giannotti *et al.*, 2002).

Agricultural Region: As a measure of exposure hazards specific to different types of agricultural activity, animal-handling regions may have an increased risk of injury compared with other types of agriculture (Gerberich *et al.*, 1993; 2001; 2003; 2004; Lee *et al.*, 1996). Agricultural region also may indirectly impact injury through hours of work (different agricultural enterprises are more time-

intensive) (Elkington, 1990; Boyle *et al.*, 1997; Lee *et al.*, 1996; Gerberich *et al.*, 2001; Cogbill *et al.*, 1985).

Alcohol Use: High alcohol use may increase risk of injury among students compared with low alcohol use. Alcohol use also may be a measure of risk-taking behavior that would increase risk of injury. Alcohol use may affect the number of hours worked due to the psychosocial impact of drinking, and the number of hours spent sleeping due to the physiologic effects of alcohol (Carskadon, 1990).

Tobacco Use: Frequent, compared with infrequent or no, smoking activity may increase risk of injury among students. It also may be a measure of risk-taking behavior that would be associated with increased risk of injury. Nicotine may impact hours of sleep due to its activity as a stimulant, although it also has sedative effects (Carskadon, 1990).

Hours of Work: Increased hours of work may increase risk of injury due to increased exposure time to hazards. Increased hours of work also may decrease hours of sleep received (Carskadon, 1990; Elkington, 1990; Boyle *et al.*, 1997; Lee *et al.*, 1996; Gerberich *et al.*, 2001; 2003; 2004).

Hours of School and Homework: Increased hours of school and time spent doing homework may be a measure of responsibility and carefulness that would decrease the risk of injury. Increased hours of school and homework also may impact risk indirectly through the hours of work, hours spent in extracurricular activities, and hours of sleep an adolescent fits into his/her schedule (Carskadon, 2002; Fukuda and Ishihara, 2002; Gold *et al.*, 1992).

Hours of Organized and/or Recreational Sports: Increased hours spent in extracurricular activities such as organized or recreational sports may increase risk of injury. Hours spent in such activities also may impact risk indirectly through the hours of work, hours spent in school/homework, and hours of sleep an adolescent fits into his/her schedule (Carskadon, 2002; Valent *et al.*, 2001) .

Time to Sleep: The time at which an adolescent goes to sleep may have an impact on the risk of injury both directly and indirectly. The direct effect would be related to increased hours of being awake, and thus, increased exposure time. Indirectly, a later time to sleep may lessen hours of sleep due to an inflexible time to rise and, thus, impact injury (Acebo *et al.*, 1997, Carskadon, 1990; 1993; 2004; Fukuda and Ishihara, 2002; Tynjala *et al.*, 1993; Thorleifsdottir *et al.*, 2002).

Hours of Sleep: The hypothesis of this analysis is that hours of sleep will be associated with risk of injury. A dichotomous variable (e.g. less than nine hours of sleep per night versus nine hours or greater as referent) was created (Acebo, *et al.*, 1997, Valent, *et al.*, 2001, Carskadon, 1990; 2002; 2004).

Data Analysis

For this analysis, the definition used for an injury event was: restriction of normal activities for four hours or more; and/or loss of consciousness, loss or awareness, or amnesia for any length of time; and/or use of professional health care. Injury responses were in a nominal format to the question “Based on this definition, were you injured?” The definition for work for this questionnaire encompassed all employment, paid or unpaid, either at home or away from home. These activities included chores or work done for the family, as well as traditional work outside of the home. A positive response to

work elicited further information on type of employment and hours of exposure.

Adolescents also were asked about the average number of hours of sleep acquired over the questionnaire time frame, both during the week nights (Sunday through Thursday) and the weekend nights (Friday and Saturday), and the average time going to sleep during the previous months.

Odds ratios and 95% confidence intervals were estimated using multivariable logistic regression (Breslow and Day, 1987). The causal model (**Figure 3**) was again used as a basis for specification of directed acyclic graphs (DAGs) for each association of interest, which informed selection of the potential confounders for the full multivariable model. Resulting models included: adolescent's gender; grade in school (as a surrogate for age); number of hours worked daily; number of hours spent per day in school or doing homework; number of daily hours involved in recreational or organized sports; tobacco and alcohol use; and the typical time at which the individual went to sleep. Risk of injury was estimated using both the usual school night (Sunday through Thursday) sleep patterns and the usual weekend sleep patterns. Students reporting nine or more hours of sleep every night (weekday and weekend), the amount of sleep reported to be needed by adolescents (Carskadon, 2002), were categorized as referent. Generalized Estimating Equations (GEEs) (Liang and Zeger, 1986) were used to adjust for correlations among multiple observations from the same person.

Aim 2:

Risk of work-related injuries among sleep-deprived Minnesota adolescents

(Chapter 5)

Work-related injury is a major concern for adolescents. Among adolescents, work is the fourth leading cause of injury, and by age 17, it is the leading cause (Brooks *et al.*, 1993). Types of injuries commonly experienced by adolescents include lacerations, contusions, abrasions, strains and strains, fractures, and dislocations (Runyan *et al.*, 2000). Data sources for these injuries are typically emergency department records, industry self-reported data, and youth self-report; however, the true burden and determinants of work-related adolescent injury, and especially the impact of sleep, is not well understood.

The purpose of this aim was to analyze data from the Youth at Work (Williams *et al.*, 2004; 2006) program, a cohort of adolescents attending public high schools throughout the rural counties of Minnesota, to examine the effects of sleep, time-consuming work habits, and the risk of injury among adolescents.

As with the first aim, univariate analyses were employed, first, to describe the characteristics of the cohort of working youth from the overall Youth at Work cohort. Cross-tabulations were used to calculate rate ratios and confidence intervals to examine if individual exposure was a risk factor or potential confounder. Based on the conceptual and causal models for this study, variables were selected to enter the multivariate model analyses.

An overall conceptual model for the occurrence of injury events, based on previous knowledge, was presented in **Figure 3**. To further investigate the assumptions

behind the analysis of work-related injury and sleep, a DAG was developed and is presented in **Figure 5** (Greenland *et al.*, 1999). As with the previous DAG, this DAG was based on previous published information, deduction from this information, previous knowledge of injury mechanisms, and data from prior research and information provided by the study advisory group, comprised of teachers, school administrators, public health nurses, safety professionals and injury epidemiologists. It was determined that the same variables described in aim 1 were pertinent in aim 2.

Data Analysis

For this analysis, the definition used for a work-related injury event was the same as for other injury events: restriction of normal activities for four hours or more; and/or loss of consciousness, loss or awareness, or amnesia for any length of time; and/or use of professional health care. Injury responses were in a nominal format to the question “Based on this definition, were you injured?” The definition for work for this questionnaire encompassed all employment, paid or unpaid, either at home or away from home. These activities included chores or work done for the family, as well as traditional work outside of the home. A positive response to work elicited further information on type of employment and hours of exposure. Adolescents also were asked about the average number of hours of sleep acquired over the questionnaire time frame, both during the week nights (Sunday through Thursday) and the weekend nights (Friday and Saturday), and the average time going to sleep during the previous months. For the first analysis, an average of sleep hours reported during the weekend and weeknight among employed adolescents was used to describe sleep quantity for each individual, and young adults who reported sleeping nine hours or more on average were categorized as referent.

For the multivariate analysis, sleep patterns were assessed from hours of sleep reported during both weeknights and weekend nights, not sleep averages, and working adolescents who reported sleeping nine hours or more were categorized as referent.

Occupations were grouped by Standard Industrial Classification (SIC) codes, and were based on previous research about teen employment in rural communities (Parker *et al.*, 2002). Overall, seven categories were used to describe the occupations: Personal Services included lawn care, babysitting, and housekeeping activities; Restaurant/Fast Food employment consisted of cooks, servers and dishwashers; Retail positions included cashiers, stock clerks and sales clerks; Professional/Medical employment was comprised of positions as varied as office staff, teacher's aides and hospital orderlies; Construction or Manufacturing workers held positions as line workers or laborers; the Entertainment or Recreation industries employed lifeguards, sports instructors, amusement park attendants and dockhands; and finally, Farm work comprised all work done on a farm or agribusiness.

Rates of work-related injury per 1,000 persons were estimated among employed adolescents in each of these seven occupational groups, for both work experience during the summer months. The average of both the usual week night (Sunday through Thursday) sleep patterns and the usual weekend sleep patterns was calculated, and this analysis was stratified by reported sleep hours. Working young adults reporting an average of nine hours of sleep or more were categorized as referent, compared with adolescents who averaged less than nine hours of sleep per night. The relative risk of work-related injury among sleep-deprived individuals compared with well-rested young adults was calculated.

Multivariate analyses were conducted using directed acyclic graphs (DAGs) to select confounders for each exposure of interest (Greenland *et al.*, 1999; Hernan *et al.*, 2002). The DAGs were based on previous published information, deduction from this information, and previous knowledge of injury mechanisms; also, considered, were data from prior research and information provided by the study advisory group, comprised of teachers, school administrators, public health nurses, safety professionals and injury epidemiologists. Generalized Estimating Equations (GEEs) (Liang and Zeger, 1986) were used to adjust for correlations among multiple observations from the same person. For this analysis, weeknight and weekend night sleep patterns were utilized more fully than in the earlier analysis to address the potential for extreme sleep deprivation and extended sleep being averaged to moderate effects. Sleep patterns were categorized into six groups, with individuals who always reported sleeping nine hours or more every weeknight and weekend night classified as referent. At the other extreme, adolescents who always reported sleeping six hours of sleep or less every night were classified as always having insufficient sleep. The sub-optimal sleep pattern included all individuals who reported always sleeping greater than six hours per night, but less than nine hours. Adolescents who reported different sleep patterns on weeknights than weekend nights make up the final categories: sleeping a fully optimal nine hours or more on either weeknights or weekend nights but sleeping less (either insufficient hours or sub-optimal hours) on other nights; or reporting insufficient sleep on either weeknights or weekend nights but sleeping optimal or sub-optimal hours on other nights.

Bias Evaluation

The study described herein utilized data from the Childhood Agricultural Trauma Evaluation System (CATES) (Williams *et al.*, 2006). Through careful study design and implementation, every attempt was made to minimize issues of bias. Potential biases were additionally assessed through sensitivity analyses evaluating the impact of potential measurement error and confounding biases on the study results (Greenland and Kleinbaum, 1983).

a. Information Bias

An important consideration in any epidemiologic study is the assessment of measurement error. Measurement error can result in a large amount of bias (Copeland *et al.*, 1977; Dosemeci *et al.*, 1990; Gilbert, 1990; Flegal *et al.*, 1991; Wacholder *et al.*, 1991). It is anticipated that there is a potential for measurement error in the reporting of both injury events and risk factors for these events, due to the self-reported nature of the information, the time-dependent memory decay, and the nature of the participants, including the role of defiance in adolescence.

Recall bias from the self-reporting of exposures on the Fall 2001 and Fall 2002 questionnaires was minimized by using a time period of three months as the exposure period of interest. The Spring questionnaire cycles, which covered the entire school year, may have had an increased risk of bias due to the longer time covered by each cycle. This concern was addressed through comprehensive training of school personnel who administered the questionnaires; however, the potential for gaps in recall exists.

Sensitivity analyses were performed to assess the likelihood of the magnitude of this error and its impact on the resulting risk estimates. While it is not technically

possible to fully “correct” risk estimates for bias due to measurement error (Greenland and Kleinbaum, 1983), using methods similar to those of Greenland and Kleinbaum, (1983), Kleinbaum *et al.*, (1982), the sensitivity analyses result in a “correction” for measurement error in the sense that upper and lower bounds for risk estimates under different plausible scenarios for measurement error can be obtained. Sensitivity analyses also were performed on potential confounding variables to evaluate the upper and lower bounds for risk estimates.

b. Selection Bias

The cohort study design is based on a complete enumeration of a population with some common feature that is, then, followed over time. The sampling protocol for the CATES study enumerated all students attending public high schools (grades 9-12) with class size greater than 25 students in all 67 counties classified as rural by the USDA. However, it is possible for selection bias to occur, either at the level of the school, the classroom, or the student. Schools ultimately chose not to participate for several reasons; many schools cited concern about “over-surveying” while others were uneasy about the time commitment by faculty and staff. At the classroom level, several teachers chose not to allow their students to participate in the CATES questionnaire due to what they perceived to be the sensitive nature of many questions and concerns about government involvement. Finally, students were allowed to refuse to participate at any time. As with bias due to measurement error, it is not possible to fully correct effect estimates for selection bias.

c. Sensitivity Analyses

Confounding

Sensitivity analyses were conducted to assess the magnitude and direction of potential bias from the omission of an unmeasured confounder that increased the odds of adolescent injury by factors of 0.5, 1, 3 and 5. Using methods described by Rothman and Greenland (1998), analyses were conducted to generate a range of estimates for the odds of injury, adjusted for the prevalence of the unmeasured confounder of the use of caffeine and other stimulants among well-rested adolescents versus sleep-deprived adolescents.

Attrition

The number of questionnaire responses generally declined throughout the two-year study. Students who supplied information during the later time periods were compared with students who completed the initial questionnaire, to assess similarities and differences in responses. Overall, comparisons showed little change in population responses, despite the decrease in the number of students completing questionnaires.

Summary

Advantages and Limitations

The NIOSH Strategic Goals call for the development, implementation and evaluation of injury prevention strategies (NIOSH (a), 1998; NIOSH (b), 1998). This research addressed those priorities by providing surveillance data analysis to support these activities and addressing deficiencies in current knowledge about rural adolescent injuries.

An important strength of this study was the size of the cohort, which was critical to this analysis. In total, 15,002 individuals completed almost 42,000 questionnaires over

a two-year period. This cohort was unique in that it did not include small sub-sets of a rural community, such as individuals injured severely enough to require hospitalization, or members of households associated with an agricultural operation, as many studies have. Rather, these data enumerated young adults who lived in rural Minnesota communities and attended public high schools.

Another important advantage of this research is that it built upon the experience of the research team members who were involved in prior major relevant population-based efforts. The involvement of the assembled highly qualified and experienced research team, that represented multiple relevant disciplines, was critical to the accomplishment of the stated aims and overall success of the effort.

Limitations of this study should be considered when interpreting results. One concern is the lack of clear association between sleep per night and an injury event, because data were collected to address average sleep per night rather than exact sleep prior to an injury event. It is anticipated that there is a potential for measurement error in the reporting of both injury events and associated exposures for these events, due to the self-reported nature of the information, the time-dependent memory decay, and the nature of the participants — the potential behavior of defiance in adolescence. All data were self-reported; thus, there was no opportunity for the research team to validate responses. Results also may reflect the potential for inaccurate recall of injuries, especially during the nine-month school year, as well as inconsistent recall of sleep hours and sleep patterns (Jenkins *et al.*, 2002; Harel *et al.*, 1994; Langley *et al.*, 1989).

Schools were randomly selected to participate; but, some bias may be anticipated which reflected the willingness of the school administration to actively engage in such

extracurricular activities. Typically, it was more likely that a school would participate if there had been a recent publicized account of work injury or if the principal or faculty had personal concerns about the work history or injury events among adolescents in the community. Therefore, this bias could potentially contribute to heightened awareness of the issues of work and injury and increased reporting.

Human Subjects

This study analyzed data from a statewide surveillance for childhood agricultural injuries among public high schools in 67 rural counties that were assigned to one of four possible agricultural regions. Information collected was used to provide information about risk factors for injuries through a cohort analysis. Standard educational techniques and methods were used to administer the questionnaires. These questionnaires were coded to maintain anonymity and the code was maintained by each school.

This study utilized data collected through self-reported questionnaires, completed by students in grades 9 through 12. Study subjects included all students who attended a public high school in one of the selected schools in a rural Minnesota county. There were no known risks associated with this research. There were no invasive procedures. All measures were facilitated by self-administered questionnaires.

All data were protected by Minnesota Statute 13.38. All written data were maintained at the Minnesota Department of Health in locked cabinets, located in locked offices; all computerized data were password-protected. Only researchers had access to study data. Schools received only summary data that pertained to their particular school and could not be used to identify individuals. Aggregate data were released to all schools at the end of the study. These data were collected under approval by the Institutional

Review Board of the Minnesota Department of Health, with additional review by the University of Minnesota Institutional Review Board.

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Table 1: Rural-Urban Continuum Codes for Metropolitan and Non-Metropolitan Counties (as of June, 1993)

Code Metropolitan Counties:	
0	Central counties of metropolitan areas of 1 million population or more
1	Fringe counties of metropolitan areas of 1 million population or more
2	Counties in metropolitan areas of 250,000 to 1 million population
3	Counties in metropolitan areas of fewer than 250,000 population
Code Non-Metropolitan Counties:	
4	Urban population of 20,000 or more, adjacent to a metropolitan area
5	Urban population of 20,000 or more, not adjacent to a metropolitan area
6	Urban population of 2,500 to 19,999, adjacent to a metropolitan area
7	Urban population of 2,500 to 19,999, not adjacent to a metropolitan area
8	Completely rural or fewer than 2,500 urban population, adjacent to a metropolitan area
9	Completely rural or fewer than 2,500 urban population, not adjacent to a metropolitan area

Table 2: Characteristics of Schools in 67 Rural Minnesota Counties, 2000

	Region 1 Swine, Corn, & Soybeans	Region 2 Dairy and Poultry	Region 3 Forestry & Wild Rice	Region 4 Grains and Sugar Beets
Total Number of Students				
9 th Grade	6752	5214	5002	3636
10 th Grade	6605	5503	5096	3639
11 th Grade	6350	5298	4734	3528
12 th Grade	6249	5236	4523	3676
Total Number of Schools				
	63	49	50	58
Maximum Grade Size				
9 th Grade	453	387	482	226
10 th Grade	433	380	544	240
11 th Grade	391	387	555	196
12 th Grade	226	240	196	227
Average Grade Size Per School				
9 th Grade	107	106	100	63
10 th Grade	105	110	102	63
11 th Grade	101	106	97	61
12 th Grade	99	105	90	63
Number of Counties				
	19	11	14	23

Table 3: Number of Schools Used to Estimate Incidence Rate of 10/100,000

Agricultural Region	Incidence Rate of 10/100,000
Region 1: Swine, Corn and Soybeans	10/63*
Region 2: Dairy and Poultry	10/49*
Region 3: Forestry and Wild Rice	10/50*
Region 4: Grains and Sugar Beets	11/58*

*Note that the denominator in each cell of the table is the actual number of schools in a region and the numerator is the sample size (number of schools needed per region).

Figure 1: Minnesota Agricultural Regions

Minnesota Agricultural Regions

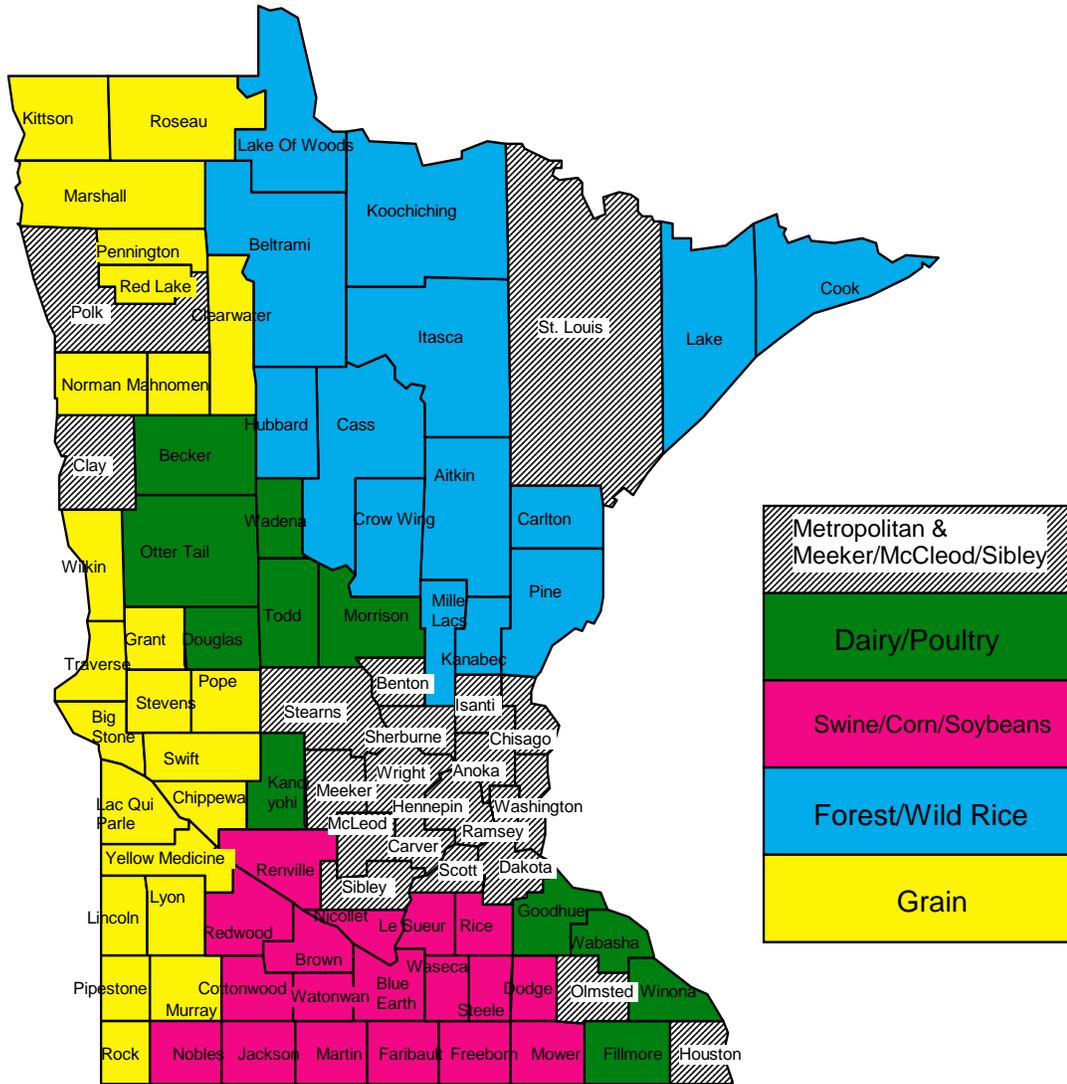


Figure 2: Flowchart of target population in CATES study

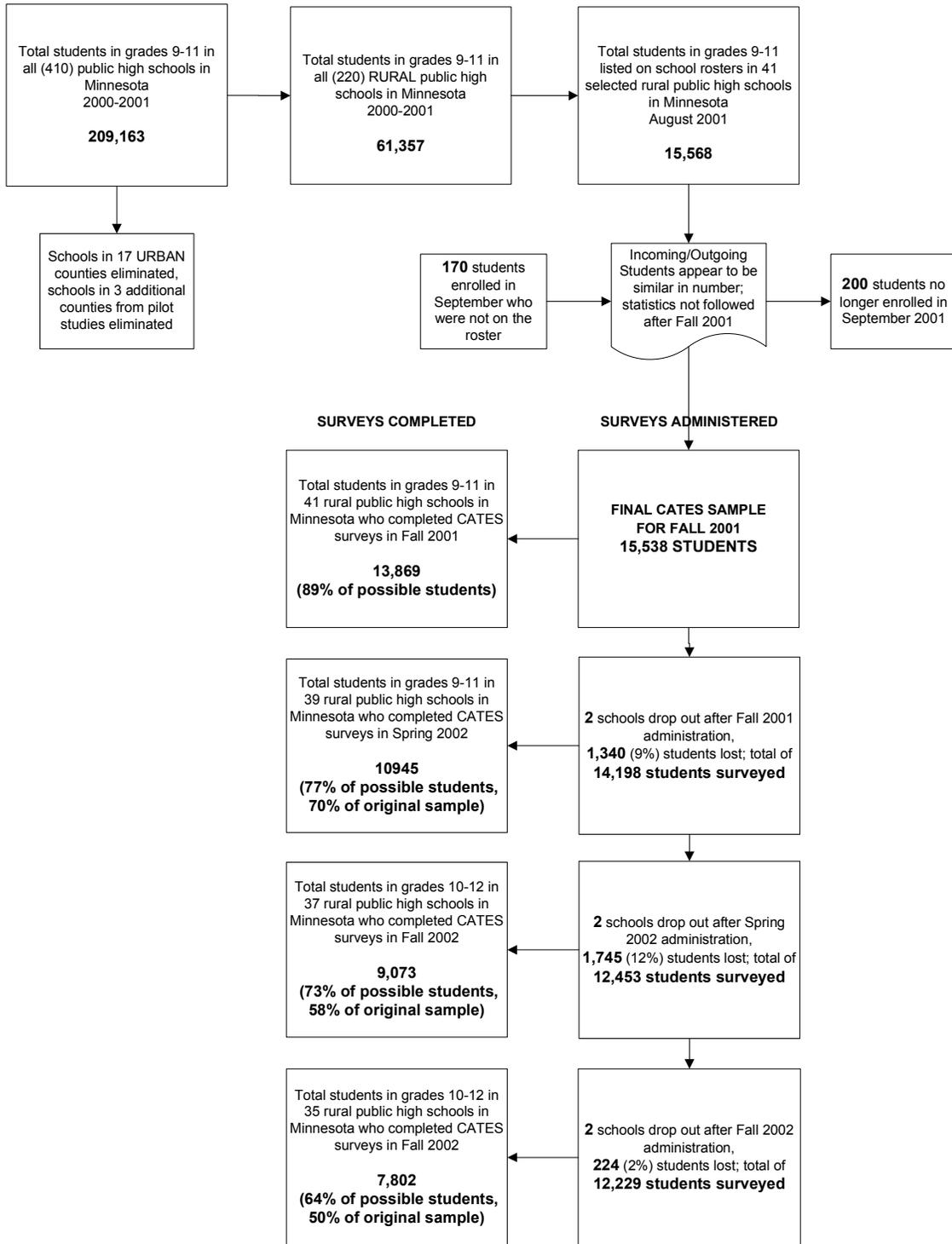


Figure 3: Risk Factors for Injury among Rural Adolescents

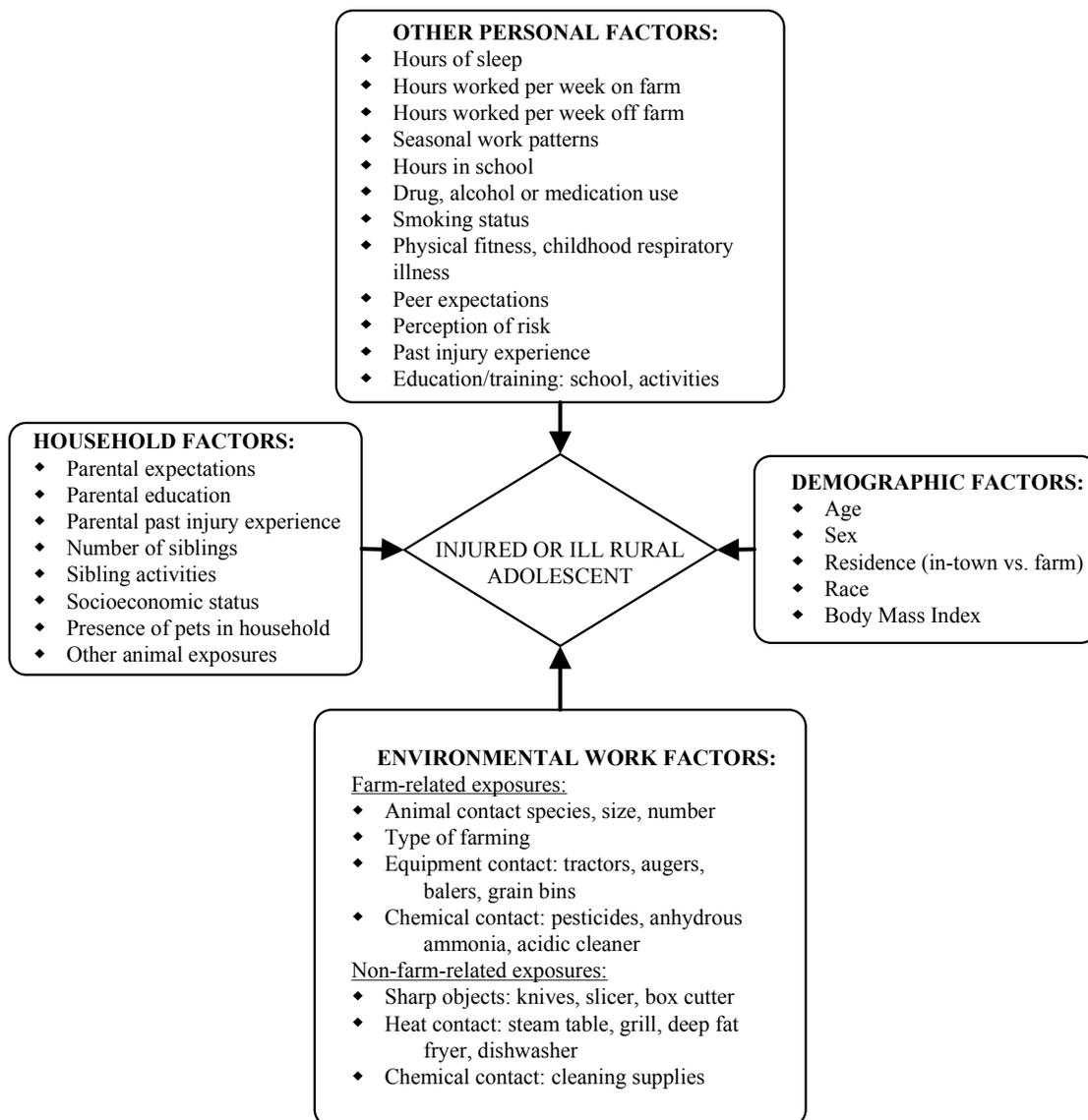


Figure 4: Causal Model for Aim 1

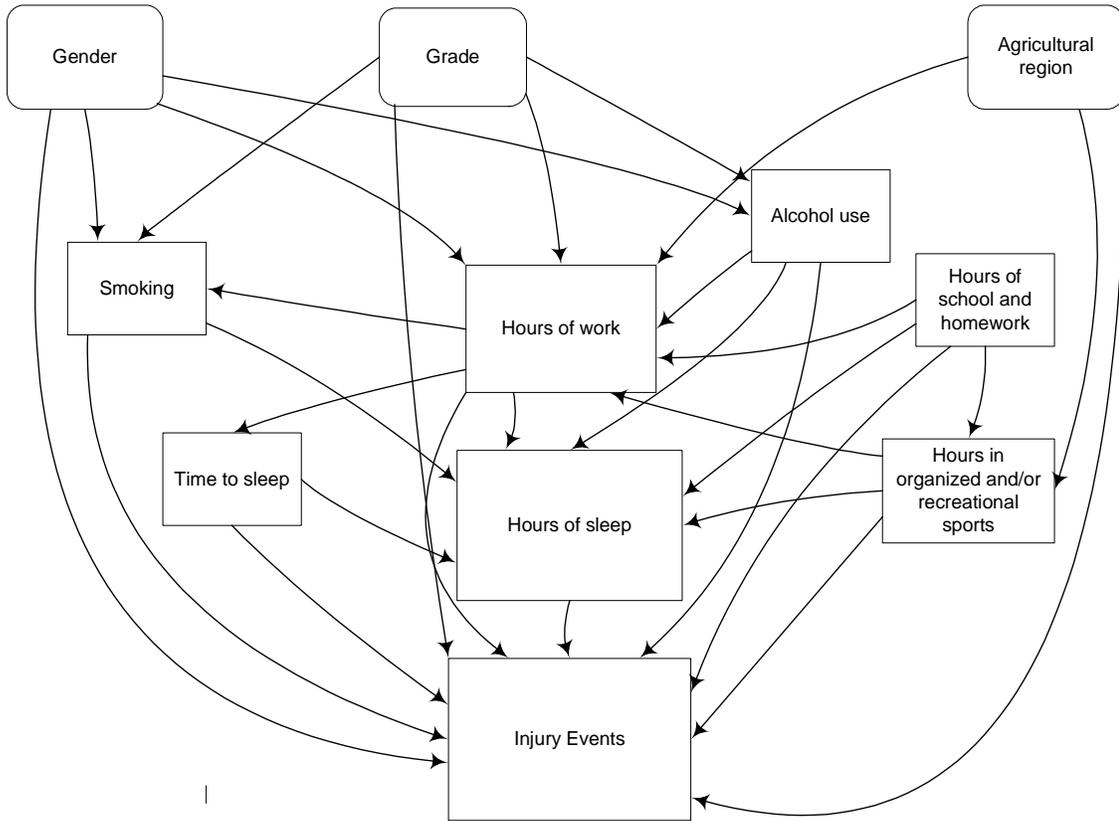
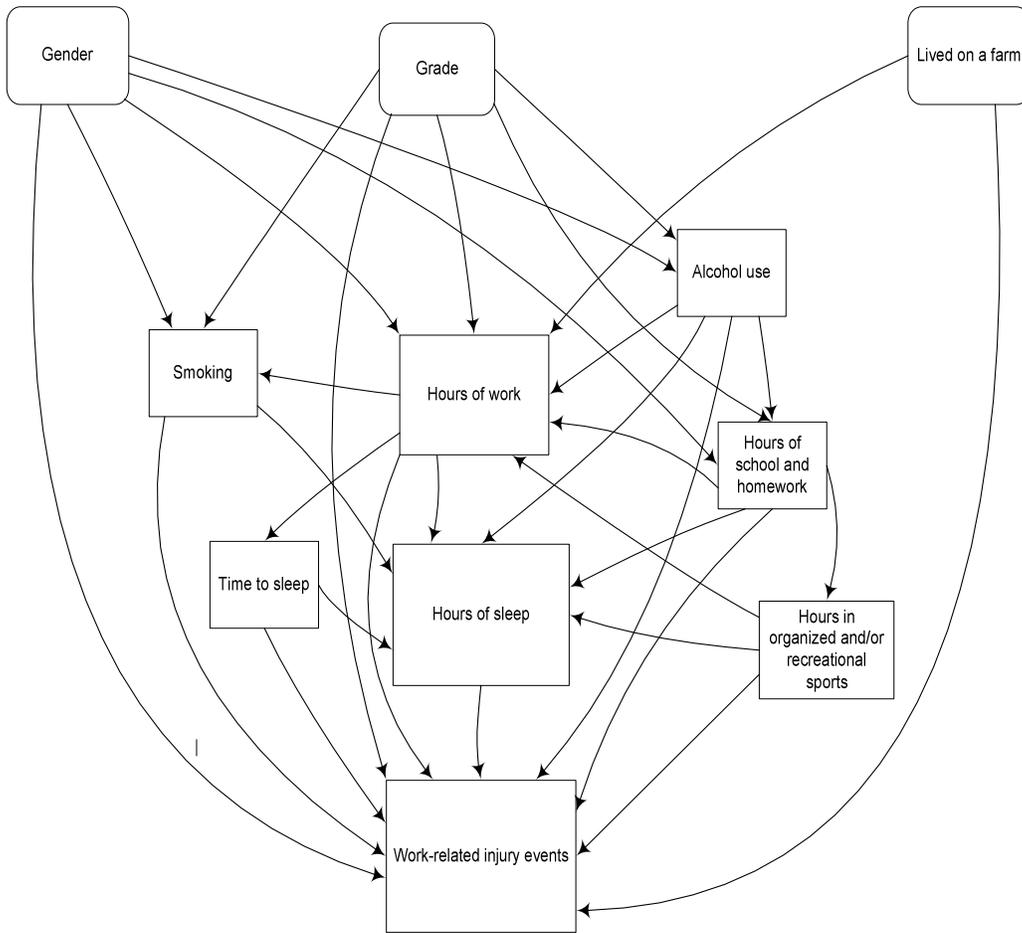


Figure 5: Causal Model for Aim 2



CHAPTER IV

SLEEP PATTERNS AND RISK OF INJURY AMONG RURAL MINNESOTA ADOLESCENTS

ABSTRACT

The purpose of this study was to determine whether an association exists between injury risk and sleep patterns among adolescents.

Youth at Work, an open cohort from 41 rural high schools in Minnesota, followed 15,002 students from 2001-2003. Data were collected through a self-completed questionnaire, distributed to each student four times during the 2001-2002 and 2002-2003 school years. Questionnaire responses described events in either the summer months (fall administration) or the school year (spring administration). A total of 41, 272 questionnaires were completed.

Risk of injury associated with sleep was estimated using sleep patterns characterized by insufficient sleep (six hours or less per night), sub-optimal sleep (greater than six hours and less than nine hours per night) and optimal sleep (nine hours or more per night) from both the usual school night (Sunday through Thursday) and the usual weekend night, for a total of nine distinct, non-overlapping sleep patterns. Adolescents reporting optimal sleep every night were categorized as referent. Multivariate analyses were conducted using directed acyclic graphs to select confounders.

While controlling for potential confounders, adolescents who reported sleeping six hours or less every night during the summer had an increased risk of injury (OR = 1.40; CI = 1.13, 1.72). Risk of injury increased further for individuals who slept six hours or less during the weekend nights in the summer, but received optimal sleep on

weeknights (OR = 1.60; CI = 1.20, 2.14). During the school year, students who reported six hours of sleep or less during school nights and sub-optimal sleep on weekend nights also had an increased risk of injury (OR = 1.53; CI = 1.07, 2.20), as did individuals who slept nine hours or longer on weekend nights but acquired insufficient sleep on school nights (OR = 1.71; CI = 1.22, 2.39).

These results indicate that sleep may play an important role in the safety of adolescents, as an increased risk of injury was found with any decrease in sleep hours, less than the suggested nine hours per night.

BACKGROUND

It is generally believed that humans need one hour of sleep for every two hours of wakefulness, and a full spectrum of health consequences may result from accumulating sleep debt (Dement, 1999). Sleep studies find that sleepiness increases with even a small reduction in nightly sleep times (Dinges *et al.*, 1997). The sleep patterns of adolescents have generated significant community concern in recent years, prompting high schools to re-evaluate scheduling and school start times to try to minimize sleepiness during classes (Carskadon, 2002).

Adolescence is a time of great developmental change, from physical, psychological, and social perspectives (Richardson and Tate, 2002). One aspect of this change is an alteration in sleep patterns; young adults, compared to preadolescents, appear to undergo a shift in sleep-wake cycles, such that they stay up later in the evening and prefer to sleep later in mornings (Carskadon, 1993; Fukuda and Ishihara, 2001). This circadian phase delay is believed to be both biological and environmental in nature, since the teen years involve increased time constraints due to work, school and social commitments as well as major endocrine alterations (Dornbusch, 2002, Giannotti *et al.*, 2002). While young adults appear to suffer from increased sleep deprivation, it is unclear how this lack of sleep may impact other aspects of adolescent life, including their safety.

Sleepiness has been identified as a risk factor for injury events among adults, usually related to driving (Connor *et al.*, 2001; Lyznicki *et al.*, 1998). Insufficient sleep also has been linked to a 61% increase in injury among rural adults (Choi *et al.*, 2006). Among younger children, several studies report that those individuals who did not get

enough sleep sustained a higher number of medically-attended injuries (Koulouglioti *et al.*, 2008; Valent *et al.*, 2001).

Among adolescents living on farms in Colorado, sleep patterns associated with increased risk of injury included oversleeping, falling asleep in afternoon class, staying up past 3:00 am, and sleeping less than an average of 8.5 hours per night (Stallones *et al.*, 2006). Decreased sleep as a risk factor for injury also was assessed among high school students in China by Lam and Yang (2007); adolescents who slept less than seven hours per night during a normal school week were two times more likely to have experienced multiple episodes of unintentional injury than those who slept seven hours or more. Yet, further study is needed to understand the role of sleep and its association with injury, in general, among adolescents.

The purpose of this study was to assess the sleep patterns among a cohort of adolescents, attending public high schools throughout the rural counties of Minnesota, to determine whether an association exists between sleep behaviors and injury outcomes.

METHODS

Overview

This study was based on data from the Youth at Work Program (Williams *et al.*, 2004; 2006), coordinated by the Minnesota Department of Health. Using a stratified cluster design, with agricultural regions as strata and schools as clusters, a sample of 41 rural schools was selected and recruited to participate in the activities of this program. For the current analysis, data from the cohort of 15,002 students, collected through questionnaires administered four times over a two year period, were used. The Institutional Review Board, Human Subjects Committee, at the University of Minnesota approved the protocol for this analysis; approval for the overall study was obtained from the Institutional Review Board at the Minnesota Department of Health.

Study Population

Data in this study were collected as part of a longitudinal study of work and injuries and illnesses among adolescents enrolled in rural Minnesota high schools. Eligible for inclusion, were 190 public high schools with at least 20 students in each grade and located in one of 67 Minnesota counties, designated as rural, according to US Department of Agriculture criteria. To achieve a more representative sample of schools and potential agricultural experiences, two additional stratification factors were used in school selection: school size (three categories) and the predominant types of agriculture at the county level (four regions). Schools within each agricultural region and size category were recruited on a random basis. The goal was to recruit four small schools, four medium schools and two large schools from each of the four agricultural regions, and one additional medium school from a sparsely populated region to ensure that the

sample accurately represented the population. By the start of the study, 41 (65%) of 63 recruited schools agreed to participate, representing a population of 15,368 students in grades 9 through 11.

Participation of schools and students was completely voluntary. Parents were contacted by letter to inform them of the study and allow them the opportunity to have their child opt out of the study. All principals completed online Human Subjects Assurance training from the U.S. Office of Human Research Protection and Federalwide Assurance of Protection for Human Subjects documentation, as required by the U.S. Department of Health and Human Services.

Data Collection

Data on demographics, work, work hours and hazards, injury, and potential injury risk factors were collected from the entire student body in grades 9-11 through a self-completed questionnaire; this was distributed to each student twice during the 2001-2002 school year, during either class periods or school-wide assemblies at each of the 41 schools. Questionnaire responses identified injury events and exposures in either the summer months (fall administration) or the school year (spring administration). The same questionnaire was administered two additional times during the 2002-2003 school year to the same students and, then in grades 10-12, in the same manner. The open cohort design allowed for students to enter or exit at any time during the two year period; each student received an individual identification number at the beginning of the program or whenever they entered. Completed surveys were scanned and results entered into a database. Data were then edited for consistency of responses, out-of-range responses, skip patterns, and missing data.

The open cohort was followed through two school years and the preceding summer months. A total of 15,002 students were surveyed during the four administration cycles of the Youth at Work program; 41,272 eligible questionnaires were completed during these two years. All four questionnaires were completed by 5,922 students. The original sample of 13,869 students accounted for an overall response rate of 89% of eligible students in 41 sampled schools. The decrease in participation represented both a decline in participating schools (reduced to 35 schools by spring 2003) and a decrease in individual student participation (89% to 68%).

Primary Variables in Analysis

For this analysis, the definition used for an injury event was: restriction of normal activities for four hours or more; and/or loss of consciousness, loss or awareness, or amnesia for any length of time; and/or use of professional health care. Injury responses were to a general question stating, “Based on this definition, were you injured?” The definition for work for this questionnaire encompassed all employment, paid or unpaid, either at home or away from home. These activities included chores or work done for the family, as well as traditional work outside of the home. Adolescents also were asked about the average number of hours of sleep acquired over the questionnaire time frame, both during the week nights (Sunday through Thursday) and the weekend nights (Friday and Saturday), and the average time going to sleep during the previous months.

Data Analysis

Risk of injury was estimated using both the usual week night (Sunday through Thursday) sleep patterns and the usual weekend sleep patterns. Students reporting nine or

more hours of sleep every night (weekday and weekend), the amount of sleep reported to be needed by adolescents (Carskadon, 2002), were categorized as referent. Insufficient sleep was categorized as six hours or less of sleep, and sub-optimal sleep included all self-reports of sleep greater than six hours and less than nine hours of sleep. In total, nine distinct sleep patterns were assessed, accounting for all possible variations in sleep patterns between week night sleep and weekend night sleep. Multivariate analyses were conducted using directed acyclic graphs (DAGs) to select confounders for each exposure of interest (Greenland *et al.*, 1999; Hernan *et al.*, 2002). The DAGs were based on previous published information, deduction from this information, and previous knowledge of injury mechanisms; also, considered, were data from prior research and information provided by the study advisory group, comprised of teachers, school administrators, public health nurses, safety professionals and injury epidemiologists. Generalized Estimating Equations (GEEs) (Liang and Zeger, 1986) were used to adjust for correlations among multiple observations from the same person. Self-reported sleep information from the summer months was analyzed separately from data reported during the school year.

Sensitivity Analysis

A sensitivity analysis was conducted to assess the magnitude and direction of potential bias from the omission of an unmeasured confounder that increased the odds of adolescent injury by factors of 0.5, 3 and 5. Using methods described by Rothman and Greenland (1998), analyses were conducted to generate a range of estimates for the odds of injury, adjusted for the prevalence of the unmeasured confounder of the use of caffeine and other stimulants among well-rested adolescents versus sleep-deprived adolescents.

Caffeine is considered to be the most widely used psychoactive substance. It is believed to be used at least weekly by as much as 98% of the population under 18 years of age, mostly in the form of carbonated beverages (Pollak and Bright, 2003); adolescents reporting high caffeine intake were almost two times more likely to report difficulty sleeping (Roehrs and Roth, 2008).

RESULTS

A total of 15,002 students from 41 different public high schools participated in the Youth at Work (Williams *et al.*, 2004; 2006) program. Questionnaires were administered twice each school year, and all responses to the questionnaires were self-reported. Among these students, 2,473 individuals (16.5%) reported experiencing at least one injury event.

Demographic Characteristics

Characteristics of the study population are presented in **Table 1**, by survey cycle. While the overall ratio of students reporting their gender as boys did not change significantly during the four cycles, the percentage of boys reporting injuries decreased from 56% in the first cycle to 48% in the final administration. The youngest students in this cohort (freshmen progressing to sophomores) reported the greatest proportions of injuries, both during the fall questionnaire administrations (38% as freshmen and 39% as sophomores) and the spring administrations (37% as freshman and 40% as sophomores).

Compared to the school year months, a greater proportion of young adults reported staying awake until after Midnight during the summer months. On average, 28% of teens stayed up past Midnight during the summer, while only 8% of students reported that they stayed up past Midnight during the school year. This difference is most notable when looking at duration of sleep, as the mean hours of sleep on week nights, that students reported acquiring, differed by as much as an hour between the summer months and the school months; students reported more sleep on weekdays in the summer months compared to the school year (8.8 hours versus 7.7 hours). The mean

hours of sleep reported on weekends remained fairly constant during both the summer and the school year — approximately eight hours per night.

About 14% of the rural adolescents reported that they lived on a farm during the two-year period. The proportion of young adults who described themselves as current smokers went up slightly from 12% to 13% over the two years, as did those who consumed alcohol more than five days per month (17% to 24%). In general, greater percentages of these individuals reported experiencing injuries, compared with the individuals who did not live on a farm, smoke or consume alcoholic beverages. Smokers were injured 50% more often than non-smokers, drinking teens showed a 30% greater rate of injury compared to non-drinkers, and there was a 20% greater rate of injury among farm, compared with non-farm residents.

Minnesota rural adolescents were involved in many time-consuming activities, including work, school, recreational activities and organized sports. While over two-thirds of the students reported working during the summer survey periods (79% and 70% for the two consecutive summers), fewer students were actively working while school was in session (62% and 54 %). Among the young adults who participated in work, about one-half of them reported working more than eight hours a day during the summer months, and approximately one-third of the adolescents continued this work schedule during the school months.

Multivariate Regression Analyses

Regression analyses were performed separately for data related to summer months (June through August), and school months (September through May), because student lifestyles and activities differed between the two periods.

Results of multivariate analyses for the summer months are presented in **Table 2**. Based on the directed acyclic graph (**Figure 1**), the variables of grade in school, gender, hours spent at work, hours spent in organized or recreational activities, tobacco use, alcohol use, and typical time going to sleep were determined to be potential confounders. While controlling for these confounders, high school students who reported insufficient amounts of sleep (six hours or less) every night, had an increased risk of injury (OR = 1.40; CI = 1.13, 1.72), compared with those who slept nine or more hours every night. Risk of injury also was elevated for individuals who slept six hours or less on weekend nights during the summer but slept more during the week nights (greater than six to less than nine hours) (OR = 1.39; CI = 1.15, 1.67). Adolescents who had considerable sleep loss (six hours or less of sleep per night) on weekend nights, although they slept nine hours or more during the week nights, were 60 percent more likely to have experienced an injury than young adults sleeping nine hours or more every night (OR = 1.60; CI = 1.20, 2.14).

Analyses related to sleep patterns and hours of sleep during the school year (**Table 3**) also were performed, controlling for the same potential confounders. High school students, who slept six hours or less during the school nights, but more on weekend nights, were particularly vulnerable to injury. For individuals sleeping sub-optimally during weekends, risk of injury increased by over 50% (OR = 1.53; CI = 1.07,

2.70); for students who slept nine hours or more, risk of injury increased more (OR = 1.71; CI = 1.22, 2.39).

Girls with any of the sleep patterns (weeknight decreased sleep, weekend decreased sleep, or constant decreased sleep), or sleep loss during both the summer months and the school year, had an increased risk of injury compared with girls reporting nine or more hours of sleep every night. The risk of injury for female adolescents with considerable (six hours or less of sleep), and constant (weeknights and weekend nights) sleep loss, was nearly double that of well-rested girls during both the summer months (OR = 1.91; CI = 1.40, 2.62), and the school year (OR = 1.56; CI = 1.00, 2.43). Making up for sleep deficit on week days by sleeping more on the weekends more than doubled the risk of injury during the summer months (OR = 2.43; CI = 1.46, 4.05). Compared to male young adults who slept nine or more hours per night, an increased risk of injury was associated with boys who had sub-optimal sleep on school nights (greater than six to less than nine hours per night), but tried to reduce the sleep debt by sleeping more on the weekend nights (OR = 1.81; (CI = 1.31, 2.48).

Age as a risk factor for injury appeared to have the greatest impact among the junior class students, during the school year, where any decrease in sleep contributed to at least a two-fold increase in risk. Risk was greatest when juniors consistently slept six hours or less per night (OR = 2.55; CI = 1.30, 5.01), or slept sub-optimal hours (OR = 2.07; CI = 1.06, 4.04). Sub-optimal sleep among juniors on week nights, during the school year — even with optimal sleep on weekend nights — also led to increased risk, compared with juniors who always slept nine hours or more (OR = 2.53; CI = 1.38, 4.65). Freshmen also experienced an increased risk of injury (OR = 2.06; CI = 1.11, 3.81)

during school months when they had a considerable sleep loss during the week and tried to regain sleep during the weekend.

Adolescents who indicated that they resided on a farm during the summer months were at an increased risk of injury if they had any amount of insufficient sleep, compared with those individuals who reported an average of nine or more hours of sleep. Decreased sleep during the school year appeared to be especially risky, as injury risk more than doubled among sleepy farm residents compared with well-rested farm dwellers; insufficient sleep every night almost tripled the risk of injury (OR = 2.95; CI = 1.18, 7.36). A five-fold increase of risk was experienced among teens who slept six or less hours during school nights but slept longer on weekends (OR = 5.44; CI = 2.03,14.5), even if the weekend sleep was optimal (OR = 5.72; CI = 1.94, 16.9). While risk of injury among sleep-deficient teens was less in the summer months than the school year, it still was notable. Among teens who slept six hours or less every night, risk of injury more than doubled, compared with teens getting the recommended nine hours of sleep (OR = 2.05; CI = 1.25, 3.36), and more than tripled among farm residents sleeping sub-optimal hours during the weekend nights (OR = 3.29; CI = 1.33, 8.13).

Time-consuming summer work schedules involving more than eight hours a day at work, coupled with a loss in sleep, led to an increased risk of injury among Minnesota rural teens, regardless of the sleep patterns. Working young adults who had insufficient sleep during weekend nights during the summer increased the risk of injury, regardless of how many hours of sleep they acquired on weeknights; with insufficient sleep, the risk was greatest (OR = 1.72; CI = 1.32, 2.24), however, even with optimal sleep working adolescents had increased risk of injury compared with well-rested adolescents (OR

=1.58; CI = 1.06, 2.36). Students who worked more than eight hours a day during the school year, and slept six hours or less during school nights, were especially vulnerable to injury, whether they slept optimal hours during the weekend nights (OR = 2.54; CI = 1.34, 4.80), sub-optimal hours of sleep (OR = 2.69; CI = 1.47, 4.94), or insufficient hours of sleep (OR = 2.24; CI = 1.26, 3.99).

Sensitivity Analyses

To determine the potential effect of an unmeasured confounder upon the results from this study, sensitivity analyses (Rothman and Greenland, 1998) were conducted for caffeine use. From these analyses, it was shown that the magnitude and direction of the effects of sleep on adolescents' risk of injury were largely unchanged when accounting for potential sources of study error. After adjusting for caffeine intake under several scenarios, decreased sleep remained a risk factor for injury among adolescents in this study. In order to nullify the effect of sleep on injury, the odds ratio for the association between caffeine use and work-related injury would have to be three-fold, with use among sleep-deprived students being twice that of well-rested adolescents.

DISCUSSION

Results from this study indicate that sleep may play an important role in the safety and health of adolescents. Compared with adolescents who slept nine hours or more per night, an increased risk of injury was found for any decrease in sleep hours. Additionally, sleep patterns may influence risk, as changes in week-night, versus weekend, sleep schedules further increased adolescent injury rates.

One of the notable findings was the increased risk of injury among girls who experienced sleep loss during the summer months, compared with well-rested females. Although this pattern did not carry over into the school year, further research is needed to assess the role of sleep among adolescent girls. While boys typically have an increased risk of injury, compared with girls, sleep did not appear to be as important a risk factor among boys during the summer. Sleep deprivation did not significantly increase risk among this population when compared with young men who slept a full nine hours per night. During the school year, however, boys who slept optimally on weekend nights but less during the school nights had an increased risk of injury.

Another important conclusion from this analysis was the increased risk of injury among sleep-deprived farm residents. The agricultural operation has unique risk exposures unlike other occupational or household environments, such as large equipment, animals, and work environments. However, the role of sleepiness among adolescent farmers, especially during the school months, may further increase these inherent risks.

Finally, there appeared to be an increased risk of injury among employed adolescents who slept less than optimal hours, compared with well-rested adolescents. During the summer months, risk was increased among working teens who slept less on

weekend nights, and during the school months, risk was increased among young workers who slept less on school nights.

Strengths and Limitations

Several strengths are important to this study. First, the size of the cohort was critical to this analysis. In total, 15,002 individuals completed almost 42,000 questionnaires over a two-year period.

This analysis was unique in that it did not include small sub-sets of a rural community, such as individuals injured severely enough to require hospitalization, or members of households associated with an agricultural operation, as many studies have. Rather, these data enumerated young adults who lived in rural Minnesota communities and attended public high schools. Thus, the increased injury risk among farm residents, compared with that of their peers, who had similar schedules and lifestyles, is noteworthy.

Limitations of this study should be considered when interpreting results. One concern is the lack of clear association between sleep per night and an injury event, because data were collected to address average sleep per night rather than exact sleep prior to an injury event. It is anticipated that there is a potential for measurement error in the reporting of both injury events and associated exposures for these events, due to the self-reported nature of the information, the time-dependent memory decay, and the nature of the participants — the potential behavior of defiance in adolescence. All data were self-reported; thus, there was no opportunity for the research team to validate responses. Results also may reflect the potential for inaccurate recall of injuries, especially during

the nine-month school year, as well as inconsistent recall of sleep hours and sleep patterns (Jenkins *et al.*, 2002; Harel *et al.*, 1994; Langley *et al.*, 1989).

Schools were randomly selected to participate; but, some bias may be anticipated which reflected the willingness of the school administration to actively engage in such extracurricular activities. Typically, it was more likely that a school would participate if there had been a recent publicized account of work injury or if the principal or faculty had personal concerns about the work history or injury events among adolescents in the community. Therefore, this bias could potentially contribute to heightened awareness of the issues of work and injury and increased reporting.

Although the study population decreased from the 13,869 students at the start of the 2001-2002 school year to 7,802 students by the end of the 2002-2003 school year, the characteristics of the student population and the effect of sleep patterns and sleep quantity remained constant. The only exception to this could be seen in the senior class, and this result was primarily due to the sparse number of seniors who participated in the first year. In total, 5,618 students completed all four questionnaire cycles, and an additional 2,128 students completed three of the four questionnaires. Thus, despite the attrition in this study, results did not appear to be affected.

While there is always a potential for bias due to unmeasured confounders, sensitivity analyses were conducted to determine the potential effect of such a confounder upon the results identified in this study. From these analyses, it was determined that the magnitude and direction of the effects of sleep on adolescents' risk of injury were largely unchanged when accounting for potential sources of study error.

Conclusions

Injury risk associated with reduced sleep, whether during weeknights or weekend nights, may have a seasonal component. During the summer months, an increased risk of injury was associated with decreased sleep during weekend nights, while during the school year, decreased sleep during school nights was a greater risk factor for injury.

Several studies have addressed the role of sleep and injury among occupational cohorts; shift workers, in particular, are believed to be chronically deprived of sleep, regular meal times, and other elements essential to the circadian clock (Gold *et al.*, 1992; Richardson *et al.*, 1989). Similar to findings from these adult studies, it appeared that sleeping optimal hours for a few nights a week to account for accumulated sleep debt did not diminish the risk of injury for students. Ideally, it would appear that students should maintain a consistent sleep pattern throughout the week to decrease their risk of injury.

Gender may have a unique role in sleep and injury research. A study of Italian high school students found differences in sleep patterns between genders; more girls than boys reported poor sleep quality, including long periods of being awake at night and early awakening (Giannotti and Cortesi, 2002). This could contribute to sleepiness, regardless of sleep patterns and hours; but, it would be especially challenging when compounded with reduced sleep.

Agricultural operations often share close proximity with rural households, and children and adolescents are exposed to many associated hazards, even if they are not employed by the operation (Gerberich *et al.*, 2003; Gerberich *et al.*, 2004; Hard *et al.*,

1999; Gerberich *et al.*, 1993). The increased risk seen among farm residents underscores the importance of intervention in this at-risk population.

The findings from this analysis are important in generating discussion about the overall importance of sleep for adolescents. While health effects from reduced sleep have been well documented recently, the role of sleepiness in the safety of teens must be considered also. Risk factors identified in this study may serve as a basis for further research and consideration of relevant intervention efforts, both during the school year and during summer months.

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Table 1: Demographic characteristics and injuries among rural adolescents in Minnesota by questionnaire time period: 2001-2003

Date Survey Given	Fall 2001				Spring 2002				Fall 2002				Spring 2003			
	June – August 2001				September – May 2001-02				June – August 2002				September – May 2002-2003			
Time Period covered by Survey	Total N = 13869	%	Injured N = 1228	%	Total N = 10945	%	Injured N = 953	%	Total N = 9073	%	Injured N = 431	%	Total N = 7802	%	Injured N = 377	%
Gender																
Boys	7032	50.7	682	55.5	5459	49.9	493	51.7	4579	50.5	225	52.2	3838	49.2	179	47.5
Girls	6737	48.6	543	44.2	5279	48.2	456	47.9	4418	48.7	202	46.9	3835	49.2	198	52.5
Unknown/Missing	100	0.7	3	0.2	207	1.9	4	0.4	76	0.8	4	0.9	129	1.7	0	0.0
Lived on a Farm																
No	11764	84.8	1021	83.1	9017	82.4	789	82.8	7624	84.0	331	76.8	6545	83.9	330	87.5
Yes	1851	13.4	192	15.6	1584	14.5	149	15.6	1290	14.2	94	21.8	1061	13.6	46	12.2
Unknown/Missing	254	1.8	15	1.2	344	3.1	15	1.6	159	1.8	6	1.4	196	2.5	1	0.3
Grade in School																
Freshman	4503	32.5	462	37.6	3450	31.5	352	36.9	0	0.0	0	0.0	0	0.0	0	0.0
Sophomore	4555	32.8	361	29.4	3719	34.0	313	32.8	3183	35.1	167	38.8	2716	34.8	151	40.1
Junior	4524	32.6	384	31.3	3471	31.7	273	28.7	3038	33.5	107	24.8	2572	33.0	115	30.5
Senior	278	2.0	21	1.7	137	1.3	12	1.3	2760	30.4	152	35.3	2366	30.3	108	28.6

Date Survey Given	Fall 2001				Spring 2002				Fall 2002				Spring 2003			
Time Period covered by Survey	June – August 2001				September – May 2001-02				June – August 2002				September – May 2002-2003			
Unknown/ Missing	9	0.1	0	0.0	168	1.5	3	0.3	92	1.0	5	1.2	148	1.9	3	0.8
Race																
White	12842	92.6	1129	91.9	10002	91.4	894	93.8	8304	91.5	388	90.0	7116	91.2	350	92.8
Not White	765	5.6	85	6.9	579	5.3	45	4.7	632	7.1	38	8.8	514	6.6	26	6.9
Unknown/ Missing	262	1.9	14	1.1	364	3.3	14	1.5	137	1.5	5	1.2	172	2.2	1	0.3
Current Smoker																
Yes	1712	12.3	223	18.2	1398	12.8	152	16.0	1209	13.3	83	19.3	1031	13.2	74	19.6
No	11737	84.6	985	80.2	9097	83.1	790	82.9	7579	83.5	335	77.7	6443	82.6	297	78.8
Unknown/ Missing	420	3.0	20	1.6	450	4.1	11	1.2	285	3.1	13	3.0	328	4.2	6	1.6
Alcohol use >5 days/month																
Yes	2405	17.3	273	22.2	2093	19.1	207	21.7	2122	23.4	130	30.2	1849	23.7	115	30.5
No	11464	82.7	955	77.8	8852	80.9	746	78.3	6951	76.6	301	69.8	5953	76.3	262	69.5
>3 hours/day in Sports																
Yes	6843	49.3	707	57.6	3919	35.8	446	46.8	3708	40.9	191	44.3	2589	33.2	154	40.9
No	7026	50.7	521	42.4	7026	64.2	507	53.2	5365	59.1	240	55.7	5213	66.8	223	59.2

Date Survey Given	Fall 2001				Spring 2002				Fall 2002				Spring 2003			
Time Period covered by Survey	June – August 2001				September – May 2001-02				June – August 2002				September – May 2002-2003			
Attend school during time period																
Yes	1131	8.2	96	7.8	10588	96.7	943	99.0	535	5.9	34	7.9	7586	97.2	371	98.4
No	12328	88.9	1093	89.0	357	3.3	0	0.0	8318	91.7	384	89.1	216	2.8	0	0.0
Unknown/ Missing	410	3.0	39	3.2	0	0.0	10	1.1	220	2.4	13	3.0	0	0.0	11	2.9
>4 hrs/day in School/doing Homework																
Yes	260	1.9	26	2.1	9112	83.3	853	89.5	126	1.4	12	2.8	5905	75.7	307	81.4
No	13609	98.1	1202	97.9	1833	16.7	100	10.5	8947	98.6	419	97.2	1897	24.3	70	18.6
Worked during survey period																
Yes	10986	79.2	985	80.2	6757	61.7	580	60.8	6371	70.2	320	74.3	4209	54.0	207	54.9
No	2669	19.2	203	16.5	3824	34.9	347	36.4	2490	27.4	80	18.6	3326	42.6	159	42.2
Unknown/ Missing	214	1.5	40	3.3	364	3.3	26	2.7	212	2.3	31	7.2	267	3.4	11	2.9

Date Survey Given	Fall 2001				Spring 2002				Fall 2002				Spring 2003			
Time Period covered by Survey	June – August 2001				September – May 2001-02				June – August 2002				September – May 2002-2003			
>8 hours/day at work																
Yes	7098	51.2	507	41.3	3665	33.5	337	35.4	4318	47.6	255	59.2	2338	30.0	127	33.7
No	6771	48.8	721	58.7	7280	66.5	616	64.6	4755	52.4	176	40.8	5464	70.0	250	66.3
Mean hours of sleep on week nights																
Mean	8.8		9.6		7.7		8.1		8.5		9.4		7.5		8/0	
S.D.	1.9		4.9		1.5		3.4		2.0		5.0		1.6		3.4	
Mean hours of sleep on weekends																
Mean	8.4		8.1		8.3		8.4		8.1		8.0		7.9		8.0	
S.D.	2.3		2.5		2.4		2.5		2.4		2.5		2.4		2.6	
Went to Sleep after Midnight																
Yes	4027	26.8	375	30.5	722	6.6	76	8.0	2669	29.4	147	34.1	729	9.3	61	16.2
No	6911	46.1	626	51.0	8836	80.7	785	82.4	4266	47.0	193	44.8	5871	75.3	265	70.3
Unknown/ Missing	4064	27.1	227	18.5	1388	12.7	92	9.7	2138	23.6	91	21.1	1202	15.4	51	13.5

Table 2: Odds ratios and 95% confidence intervals for reduced sleep during the **summer months** as a risk factor for injury among Minnesota Adolescents, 2001-2003

Characteristics	Week Night Sleep	Weekend Night Sleep	N Injuries	Odds Ratio	95% Confidence Interval
Full Model¹					
	≤ 6 hrs	≤ 6 hrs	135	1.40	1.13,1.72
	≤ 6 hrs	> 6, <9 hrs	32	1.31	0.89,1.92
	≤ 6 hrs	≥ 9 hrs	22	1.04	0.67,1.63
	> 6, < 9 hrs	≤ 6 hrs	117	1.30	1.04,1.62
	> 6, < 9 hrs	> 6, < 9 hrs	394	1.16	1.00,1.34
	> 6, < 9 hrs	≥ 9 hrs	160	1.05	0.87,1.26
	≥ 9 hrs	≤ 6 hrs	56	1.60	1.20,2.14
	≥ 9 hrs	> 6, < 9 hrs	185	1.07	0.90,1.29
	≥ 9 hrs	≥ 9 hrs	481	<i>Referent</i>	
Gender²					
Boys	≤ 6 hrs	≤ 6 hrs	72	1.05	0.79,1.38
	≤ 6 hrs	> 6, <9 hrs	13	0.72	0.40,1.30
	≤ 6 hrs	≥ 9 hrs	18	1.12	0.68,1.86
	> 6, < 9 hrs	≤ 6 hrs	67	1.03	0.76,1.38
	> 6, < 9 hrs	> 6, < 9 hrs	222	0.98	0.81,1.18
	> 6, < 9 hrs	≥ 9 hrs	88	0.85	0.66,1.10
	≥ 9 hrs	≤ 6 hrs	31	1.37	0.92,2.03
	≥ 9 hrs	> 6, < 9 hrs	83	0.92	0.71,1.19
	≥ 9 hrs	≥ 9 hrs	267	<i>Referent</i>	
Girls	≤ 6 hrs	≤ 6 hrs	63	1.91	1.40,2.62
	≤ 6 hrs	> 6, <9 hrs	19	2.43	1.46,4.05
	≤ 6 hrs	≥ 9 hrs	4	0.64	0.23,1.76
	> 6, < 9 hrs	≤ 6 hrs	50	1.69	1.21,2.36
	> 6, < 9 hrs	> 6, < 9 hrs	172	1.38	1.11,1.72
	> 6, < 9 hrs	≥ 9 hrs	72	1.32	0.99,1.75
	≥ 9 hrs	≤ 6 hrs	25	1.96	1.28,3.01
	≥ 9 hrs	> 6, < 9 hrs	102	1.27	1.00,1.63
	≥ 9 hrs	≥ 9 hrs	214	<i>Referent</i>	
Live on Farm³					
Yes	≤ 6 hrs	≤ 6 hrs	30	2.05	1.25,3.36
	≤ 6 hrs	> 6, <9 hrs	7	3.29	1.33,8.13
	≤ 6 hrs	≥ 9 hrs	6	2.18	0.88,5.41
	> 6, < 9 hrs	≤ 6 hrs	20	1.36	0.77,2.42
	> 6, < 9 hrs	> 6, < 9 hrs	100	1.77	1.21,2.58
	> 6, < 9 hrs	≥ 9 hrs	14	0.76	0.41,1.42
	≥ 9 hrs	≤ 6 hrs	11	2.21	1.12,4.39
	≥ 9 hrs	> 6, < 9 hrs	29	1.33	0.82,2.16
	≥ 9 hrs	≥ 9 hrs	53	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	105	1.30	1.03,1.65

	≤ 6 hrs	$> 6, < 9$ hrs	25	1.13	0.73,1.74
	≤ 6 hrs	≥ 9 hrs	16	0.87	0.51,1.48
	$> 6, < 9$ hrs	≤ 6 hrs	97	1.33	1.04,1.68
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	294	1.06	0.91,1.25
	$> 6, < 9$ hrs	≥ 9 hrs	146	1.09	0.89,1.33
	≥ 9 hrs	≤ 6 hrs	45	1.50	1.08,2.07
	≥ 9 hrs	$> 6, < 9$ hrs	156	1.04	0.86,1.27
	≥ 9 hrs	≥ 9 hrs	428	<i>Referent</i>	
Grade in School⁴					
Freshman	≤ 6 hrs	≤ 6 hrs	23	1.32	0.82,2.11
	≤ 6 hrs	$> 6, < 9$ hrs	4	0.88	0.31,2.54
	≤ 6 hrs	≥ 9 hrs	2	0.55	0.13,2.24
	$> 6, < 9$ hrs	≤ 6 hrs	25	1.19	0.76,1.87
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	104	1.45	1.11,1.89
	$> 6, < 9$ hrs	≥ 9 hrs	36	0.93	0.64,1.37
	≥ 9 hrs	≤ 6 hrs	24	2.78	1.67,4.62
	≥ 9 hrs	$> 6, < 9$ hrs	53	1.01	0.73,1.39
	≥ 9 hrs	≥ 9 hrs	173	<i>Referent</i>	
Sophomore	≤ 6 hrs	≤ 6 hrs	41	1.30	0.91,1.85
	≤ 6 hrs	$> 6, < 9$ hrs	8	1.17	0.55,2.48
	≤ 6 hrs	≥ 9 hrs	10	1.46	0.75,2.83
	$> 6, < 9$ hrs	≤ 6 hrs	37	1.54	1.05,2.25
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	124	1.16	0.91,1.48
	$> 6, < 9$ hrs	≥ 9 hrs	37	0.80	0.55,1.16
	≥ 9 hrs	≤ 6 hrs	11	0.85	0.45,1.61
	≥ 9 hrs	$> 6, < 9$ hrs	63	1.08	0.80,1.46
	≥ 9 hrs	≥ 9 hrs	167	<i>Referent</i>	
Junior	≤ 6 hrs	≤ 6 hrs	48	1.38	0.96,1.98
	≤ 6 hrs	$> 6, < 9$ hrs	14	1.62	0.90,2.94
	≤ 6 hrs	≥ 9 hrs	6	0.73	0.32,1.67
	$> 6, < 9$ hrs	≤ 6 hrs	39	1.22	0.82,1.81
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	121	1.02	0.78,1.34
	$> 6, < 9$ hrs	≥ 9 hrs	60	1.18	0.85,1.64
	≥ 9 hrs	≤ 6 hrs	17	1.74	1.00,3.02
	≥ 9 hrs	$> 6, < 9$ hrs	57	1.15	0.83,1.61
	≥ 9 hrs	≥ 9 hrs	114	<i>Referent</i>	
Senior	≤ 6 hrs	≤ 6 hrs	23	1.67	0.91,3.09
	≤ 6 hrs	$> 6, < 9$ hrs	6	1.47	0.58,3.75
	≤ 6 hrs	≥ 9 hrs	4	1.74	0.58,5.19
	$> 6, < 9$ hrs	≤ 6 hrs	16	1.14	0.58,2.23
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	45	0.96	0.58,1.57
	$> 6, < 9$ hrs	≥ 9 hrs	27	1.53	0.88,2.65
	≥ 9 hrs	≤ 6 hrs	4	1.07	0.34,3.36
	≥ 9 hrs	$> 6, < 9$ hrs	12	0.83	0.40,1.70

	≥ 9 hrs	≥ 9 hrs	27	<i>Referent</i>	
Current Smoker⁵					
Yes	≤ 6 hrs	≤ 6 hrs	50	1.37	0.92,2.04
	≤ 6 hrs	$> 6, < 9$ hrs	5	0.75	0.28,1.99
	≤ 6 hrs	≥ 9 hrs	8	1.10	0.52,2.38
	$> 6, < 9$ hrs	≤ 6 hrs	46	1.41	0.92,2.14
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	54	0.99	0.67,1.47
	$> 6, < 9$ hrs	≥ 9 hrs	25	1.10	0.67,1.82
	≥ 9 hrs	≤ 6 hrs	16	1.10	0.62,1.93
	≥ 9 hrs	$> 6, < 9$ hrs	24	0.77	0.47,1.26
	≥ 9 hrs	≥ 9 hrs	67	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	85	1.36	1.06,1.75
	≤ 6 hrs	$> 6, < 9$ hrs	27	1.54	1.02,2.32
	≤ 6 hrs	≥ 9 hrs	14	0.98	0.57,1.71
	$> 6, < 9$ hrs	≤ 6 hrs	71	1.19	0.91,1.56
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	340	1.19	1.01,1.38
	$> 6, < 9$ hrs	≥ 9 hrs	135	1.04	0.84,1.27
	≥ 9 hrs	≤ 6 hrs	40	1.82	1.30,2.56
	≥ 9 hrs	$> 6, < 9$ hrs	161	1.12	0.93,1.36
	≥ 9 hrs	≥ 9 hrs	414	<i>Referent</i>	
Alcohol Use > 5 days/month⁶					
Yes	≤ 6 hrs	≤ 6 hrs	59	1.38	0.96,1.97
	≤ 6 hrs	$> 6, < 9$ hrs	8	0.92	0.42,2.04
	≤ 6 hrs	≥ 9 hrs	12	1.35	0.67,2.65
	$> 6, < 9$ hrs	≤ 6 hrs	42	1.02	0.68,1.53
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	75	0.96	0.69,1.35
	$> 6, < 9$ hrs	≥ 9 hrs	35	1.13	0.74,1.72
	≥ 9 hrs	≤ 6 hrs	25	1.60	1.00,2.58
	≥ 9 hrs	$> 6, < 9$ hrs	42	1.22	0.83,1.80
	≥ 9 hrs	≥ 9 hrs	85	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	76	1.36	1.04,1.77
	≤ 6 hrs	$> 6, < 9$ hrs	24	1.55	1.01,2.39
	≤ 6 hrs	≥ 9 hrs	10	0.78	0.41,1.48
	$> 6, < 9$ hrs	≤ 6 hrs	75	1.47	1.13,1.92
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	319	1.20	1.02,1.41
	$> 6, < 9$ hrs	≥ 9 hrs	125	1.03	0.83,1.27
	≥ 9 hrs	≤ 6 hrs	31	1.53	1.04,2.24
	≥ 9 hrs	$> 6, < 9$ hrs	143	1.04	0.85,1.27
	≥ 9 hrs	≥ 9 hrs	396	<i>Referent</i>	
>3 hours/day in Sports⁷					
Yes	≤ 6 hrs	≤ 6 hrs	69	1.34	1.01,1.79
	≤ 6 hrs	$> 6, < 9$ hrs	17	1.30	0.76,2.20

	≤ 6 hrs	≥ 9 hrs	13	1.10	0.61,1.98
	$> 6, < 9$ hrs	≤ 6 hrs	74	1.40	1.06,1.86
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	190	1.08	0.88,1.32
	$> 6, < 9$ hrs	≥ 9 hrs	81	0.95	0.73,1.24
	≥ 9 hrs	≤ 6 hrs	35	1.63	1.13,2.36
	≥ 9 hrs	$> 6, < 9$ hrs	107	1.07	0.84,1.35
	≥ 9 hrs	≥ 9 hrs	272	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	66	1.44	1.07,1.94
	≤ 6 hrs	$> 6, < 9$ hrs	15	1.33	0.76,2.33
	≤ 6 hrs	≥ 9 hrs	9	1.00	0.51,1.97
	$> 6, < 9$ hrs	≤ 6 hrs	43	1.16	0.81,1.66
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	204	1.23	1.01,1.51
	$> 6, < 9$ hrs	≥ 9 hrs	79	1.16	0.88,1.52
	≥ 9 hrs	≤ 6 hrs	21	1.50	0.93,2.43
	≥ 9 hrs	$> 6, < 9$ hrs	78	1.07	0.82,1.40
	≥ 9 hrs	≥ 9 hrs	209	<i>Referent</i>	
> 8 hours/day at work⁸					
Yes	≤ 6 hrs	≤ 6 hrs	99	1.72	1.32,2.24
	≤ 6 hrs	$> 6, < 9$ hrs	22	1.56	0.97,2.51
	≤ 6 hrs	≥ 9 hrs	16	1.42	0.82,2.47
	$> 6, < 9$ hrs	≤ 6 hrs	82	1.41	1.06,1.87
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	255	1.20	0.99,1.45
	$> 6, < 9$ hrs	≥ 9 hrs	100	1.12	0.87,1.44
	≥ 9 hrs	≤ 6 hrs	30	1.58	1.06,2.36
	≥ 9 hrs	$> 6, < 9$ hrs	109	1.12	0.88,1.42
	≥ 9 hrs	≥ 9 hrs	227	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	36	0.96	0.67,1.38
	≤ 6 hrs	$> 6, < 9$ hrs	10	1.04	0.53,2.01
	≤ 6 hrs	≥ 9 hrs	6	0.61	0.26,1.40
	$> 6, < 9$ hrs	≤ 6 hrs	35	1.13	0.78,1.64
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	139	1.13	0.90,1.40
	$> 6, < 9$ hrs	≥ 9 hrs	60	0.95	0.71,1.28
	≥ 9 hrs	≤ 6 hrs	26	1.63	1.06,2.51
	≥ 9 hrs	$> 6, < 9$ hrs	76	1.04	0.79,1.36
	≥ 9 hrs	≥ 9 hrs	254	<i>Referent</i>	
Went to sleep after Midnight⁹					
Yes	≤ 6 hrs	≤ 6 hrs	63	1.23	0.90,1.67
	≤ 6 hrs	$> 6, < 9$ hrs	15	1.24	0.69,2.22
	≤ 6 hrs	≥ 9 hrs	10	0.99	0.48,2.03
	$> 6, < 9$ hrs	≤ 6 hrs	37	1.01	0.70,1.47
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	86	0.88	0.67,1.15
	$> 6, < 9$ hrs	≥ 9 hrs	44	1.25	0.88,1.79
	≥ 9 hrs	≤ 6 hrs	23	1.25	0.80,1.97

	≥ 9 hrs	$> 6, < 9$ hrs	52	0.99	0.72,1.37
	≥ 9 hrs	≥ 9 hrs	174	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	33	1.56	1.05,2.30
	≤ 6 hrs	$> 6, < 9$ hrs	12	1.81	0.96,3.41
	≤ 6 hrs	≥ 9 hrs	4	0.65	0.23,1.81
	$> 6, < 9$ hrs	≤ 6 hrs	52	1.50	1.06,2.12
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	251	1.42	1.16,1.73
	$> 6, < 9$ hrs	≥ 9 hrs	93	1.03	0.80,1.34
	≥ 9 hrs	≤ 6 hrs	21	2.16	1.35,3.46
	≥ 9 hrs	$> 6, < 9$ hrs	93	0.99	0.77,1.28
	≥ 9 hrs	≥ 9 hrs	222	<i>Referent</i>	

1-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep

2-models included grade in school, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

3-models included gender, grade in school, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

4-models included gender, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

5-models included gender, grade in school, live on farm, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

6-model included gender, grade in school, live on farm, smoking status, hours in organized/recreational sports, hours at work, and time to sleep.

7-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours at work, and time to sleep.

8-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and time to sleep.

9-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and hours at work.

Table 3: Odds ratios and 95% confidence intervals for reduced sleep during the school year as a risk factor for injury among Minnesota Adolescents, 2001-2003

Characteristics	Week Night Sleep	Weekend Night Sleep	N Injuries	Odds Ratio	95% Confidence Interval
Full Model¹					
	≤ 6 hrs	≤ 6 hrs	88	1.29	0.95,1.74
	≤ 6 hrs	> 6, <9 hrs	49	1.53	1.07,2.20
	≤ 6 hrs	≥ 9 hrs	61	1.71	1.22,2.39
	> 6, < 9 hrs	≤ 6 hrs	120	1.33	1.00,1.77
	> 6, < 9 hrs	> 6, < 9 hrs	341	1.15	0.91,1.47
	> 6, < 9 hrs	≥ 9 hrs	460	1.52	1.20,1.92
	≥ 9 hrs	≤ 6 hrs	16	1.17	0.69,2.00
	≥ 9 hrs	> 6, < 9 hrs	60	1.28	0.92,1.79
	≥ 9 hrs	≥ 9 hrs	90	<i>Referent</i>	
Gender²					
Boys	≤ 6 hrs	≤ 6 hrs	45	1.09	0.72,1.66
	≤ 6 hrs	> 6, <9 hrs	21	1.58	0.93,2.67
	≤ 6 hrs	≥ 9 hrs	30	1.99	1.24,3.19
	> 6, < 9 hrs	≤ 6 hrs	67	1.28	0.87,1.89
	> 6, < 9 hrs	> 6, < 9 hrs	158	1.12	0.81,1.56
	> 6, < 9 hrs	≥ 9 hrs	232	1.81	1.31,2.48
	≥ 9 hrs	≤ 6 hrs	10	1.14	0.58,2.24
	≥ 9 hrs	> 6, < 9 hrs	35	1.31	0.84,2.05
	≥ 9 hrs	≥ 9 hrs	49	<i>Referent</i>	
Girls	≤ 6 hrs	≤ 6 hrs	43	1.56	1.00,2.43
	≤ 6 hrs	> 6, <9 hrs	28	1.46	0.89,2.40
	≤ 6 hrs	≥ 9 hrs	31	1.47	0.91,2.38
	> 6, < 9 hrs	≤ 6 hrs	53	1.38	0.90,2.12
	> 6, < 9 hrs	> 6, < 9 hrs	183	1.15	0.81,1.63
	> 6, < 9 hrs	≥ 9 hrs	228	1.28	0.91,1.80
	≥ 9 hrs	≤ 6 hrs	6	1.20	0.50,2.91
	≥ 9 hrs	> 6, < 9 hrs	25	1.25	0.76,2.06
	≥ 9 hrs	≥ 9 hrs	41	<i>Referent</i>	
Live on Farm³					
Yes	≤ 6 hrs	≤ 6 hrs	21	2.95	1.18,7.36
	≤ 6 hrs	> 6, <9 hrs	14	5.44	2.03,14.5
	≤ 6 hrs	≥ 9 hrs	8	5.72	1.94,16.9
	> 6, < 9 hrs	≤ 6 hrs	26	3.21	1.30,7.95
	> 6, < 9 hrs	> 6, < 9 hrs	60	2.29	1.00,5.25
	> 6, < 9 hrs	≥ 9 hrs	44	2.84	1.22,6.59
	≥ 9 hrs	≤ 6 hrs	3	1.88	0.49,7.28
	≥ 9 hrs	> 6, < 9 hrs	8	1.82	0.63,5.31
	≥ 9 hrs	≥ 9 hrs	6	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	67	1.14	0.82,1.59

	≤ 6 hrs	> 6, <9 hrs	35	1.21	0.81,1.83
	≤ 6 hrs	≥ 9 hrs	53	1.51	1.06,2.16
	> 6, < 9 hrs	≤ 6 hrs	94	1.17	0.86,1.59
	> 6, < 9 hrs	> 6, < 9 hrs	281	1.07	0.83,1.38
	> 6, < 9 hrs	≥ 9 hrs	416	1.42	1.11,1.81
	≥ 9 hrs	≤ 6 hrs	13	1.10	0.61,2.00
	≥ 9 hrs	> 6, < 9 hrs	52	1.26	0.88,1.79
	≥ 9 hrs	≥ 9 hrs	84	<i>Referent</i>	
Grade in School⁴					
Freshman	≤ 6 hrs	≤ 6 hrs	14	1.01	0.52,1.97
	≤ 6 hrs	> 6, <9 hrs	8	1.38	0.62,3.10
	≤ 6 hrs	≥ 9 hrs	18	2.06	1.11,3.81
	> 6, < 9 hrs	≤ 6 hrs	33	1.47	0.88,2.46
	> 6, < 9 hrs	> 6, < 9 hrs	81	1.25	0.83,1.88
	> 6, < 9 hrs	≥ 9 hrs	118	1.35	0.91,2.01
	≥ 9 hrs	≤ 6 hrs	6	1.29	0.50,3.35
	≥ 9 hrs	> 6, < 9 hrs	24	1.44	0.83,2.49
	≥ 9 hrs	≥ 9 hrs	37	<i>Referent</i>	
Sophomore	≤ 6 hrs	≤ 6 hrs	29	0.96	0.57,1.61
	≤ 6 hrs	> 6, <9 hrs	20	1.64	0.92,2.92
	≤ 6 hrs	≥ 9 hrs	20	1.39	0.78,2.49
	> 6, < 9 hrs	≤ 6 hrs	34	0.98	0.60,1.61
	> 6, < 9 hrs	> 6, < 9 hrs	115	1.01	0.68,1.50
	> 6, < 9 hrs	≥ 9 hrs	180	1.41	0.97,2.06
	≥ 9 hrs	≤ 6 hrs	7	1.23	0.53,2.84
	≥ 9 hrs	> 6, < 9 hrs	17	0.94	0.52,1.71
	≥ 9 hrs	≥ 9 hrs	35	<i>Referent</i>	
Junior	≤ 6 hrs	≤ 6 hrs	34	2.55	1.30,5.01
	≤ 6 hrs	> 6, <9 hrs	12	1.57	0.69,3.56
	≤ 6 hrs	≥ 9 hrs	11	1.66	0.72,3.85
	> 6, < 9 hrs	≤ 6 hrs	38	2.07	1.06,4.04
	> 6, < 9 hrs	> 6, < 9 hrs	111	1.71	0.93,3.14
	> 6, < 9 hrs	≥ 9 hrs	139	2.53	1.38,4.65
	≥ 9 hrs	≤ 6 hrs	2	0.90	0.20,4.09
	≥ 9 hrs	> 6, < 9 hrs	13	1.72	0.77,3.85
	≥ 9 hrs	≥ 9 hrs	12	<i>Referent</i>	
Senior	≤ 6 hrs	≤ 6 hrs	11	0.88	0.31,2.48
	≤ 6 hrs	> 6, <9 hrs	9	1.68	0.58,4.89
	≤ 6 hrs	≥ 9 hrs	12	2.04	0.75,5.57
	> 6, < 9 hrs	≤ 6 hrs	15	1.06	0.39,2.84
	> 6, < 9 hrs	> 6, < 9 hrs	34	0.78	0.32,1.91
	> 6, < 9 hrs	≥ 9 hrs	23	0.81	0.32,2.03
	≥ 9 hrs	≤ 6 hrs	1	0.73	0.08,6.70
	≥ 9 hrs	> 6, < 9 hrs	6	1.43	0.44,4.64

	≥ 9 hrs	≥ 9 hrs	6	<i>Referent</i>	
Current Smoker⁵					
Yes	≤ 6 hrs	≤ 6 hrs	33	1.18	0.59,2.37
	≤ 6 hrs	$> 6, < 9$ hrs	14	1.67	0.73,3.82
	≤ 6 hrs	≥ 9 hrs	21	2.10	0.98,4.52
	$> 6, < 9$ hrs	≤ 6 hrs	38	1.21	0.60,2.44
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	38	0.95	0.48,1.89
	$> 6, < 9$ hrs	≥ 9 hrs	49	1.10	0.56,2.15
	≥ 9 hrs	≤ 6 hrs	7	1.33	0.48,3.68
	≥ 9 hrs	$> 6, < 9$ hrs	6	1.07	0.38,3.06
	≥ 9 hrs	≥ 9 hrs	12	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	55	1.27	0.90,1.81
	≤ 6 hrs	$> 6, < 9$ hrs	35	1.44	0.95,2.18
	≤ 6 hrs	≥ 9 hrs	40	1.52	1.02,2.25
	$> 6, < 9$ hrs	≤ 6 hrs	82	1.32	0.96,1.83
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	303	1.19	0.92,1.54
	$> 6, < 9$ hrs	≥ 9 hrs	411	1.59	1.24,2.03
	≥ 9 hrs	≤ 6 hrs	9	0.99	0.50,1.96
	≥ 9 hrs	$> 6, < 9$ hrs	54	1.31	0.92,1.87
	≥ 9 hrs	≥ 9 hrs	78	<i>Referent</i>	
Alcohol Use > 5 days/month⁶					
Yes	≤ 6 hrs	≤ 6 hrs	37	1.26	0.66,2.39
	≤ 6 hrs	$> 6, < 9$ hrs	16	1.90	0.90,4.01
	≤ 6 hrs	≥ 9 hrs	25	2.69	1.35,5.35
	$> 6, < 9$ hrs	≤ 6 hrs	47	1.28	0.68,2.39
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	68	1.22	0.67,2.21
	$> 6, < 9$ hrs	≥ 9 hrs	86	1.69	0.93,3.07
	≥ 9 hrs	≤ 6 hrs	8	1.25	0.50,3.14
	≥ 9 hrs	$> 6, < 9$ hrs	13	1.50	0.69,3.28
	≥ 9 hrs	≥ 9 hrs	14	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	51	1.34	0.93,1.93
	≤ 6 hrs	$> 6, < 9$ hrs	33	1.43	0.93,2.20
	≤ 6 hrs	≥ 9 hrs	36	1.42	0.95,2.14
	$> 6, < 9$ hrs	≤ 6 hrs	73	1.41	1.01,1.97
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	273	1.15	0.88,1.50
	$> 6, < 9$ hrs	≥ 9 hrs	374	1.49	1.16,1.92
	≥ 9 hrs	≤ 6 hrs	8	1.04	0.50,2.14
	≥ 9 hrs	$> 6, < 9$ hrs	47	1.24	0.86,1.80
	≥ 9 hrs	≥ 9 hrs	76	<i>Referent</i>	
>3 hours/day in Sports⁷					
Yes	≤ 6 hrs	≤ 6 hrs	46	1.44	0.92,2.25
	≤ 6 hrs	$> 6, < 9$ hrs	32	2.11	1.28,3.47

	≤ 6 hrs	≥ 9 hrs	28	1.66	1.00,2.77
	> 6, < 9 hrs	≤ 6 hrs	57	1.32	0.86,2.03
	> 6, < 9 hrs	> 6, < 9 hrs	144	1.22	0.84,1.77
	> 6, < 9 hrs	≥ 9 hrs	196	1.75	1.22,2.51
	≥ 9 hrs	≤ 6 hrs	10	1.27	0.61,2.65
	≥ 9 hrs	> 6, < 9 hrs	26	1.20	0.72,2.00
	≥ 9 hrs	≥ 9 hrs	39	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	42	1.17	0.77,1.78
	≤ 6 hrs	> 6, < 9 hrs	17	1.03	0.58,1.81
	≤ 6 hrs	≥ 9 hrs	33	1.76	1.11,2.76
	> 6, < 9 hrs	≤ 6 hrs	63	1.37	0.93,2.02
	> 6, < 9 hrs	> 6, < 9 hrs	197	1.12	0.82,1.55
	> 6, < 9 hrs	≥ 9 hrs	264	1.39	1.02,1.90
	≥ 9 hrs	≤ 6 hrs	6	1.03	0.44,2.39
	≥ 9 hrs	> 6, < 9 hrs	34	1.36	0.87,2.12
	≥ 9 hrs	≥ 9 hrs	51	<i>Referent</i>	
> 8 hours/day at work⁸					
Yes	≤ 6 hrs	≤ 6 hrs	48	2.24	1.26,3.99
	≤ 6 hrs	> 6, < 9 hrs	30	2.69	1.47,4.94
	≤ 6 hrs	≥ 9 hrs	24	2.54	1.34,4.80
	> 6, < 9 hrs	≤ 6 hrs	45	1.35	0.76,2.42
	> 6, < 9 hrs	> 6, < 9 hrs	121	1.27	0.76,2.11
	> 6, < 9 hrs	≥ 9 hrs	133	1.74	1.05,2.90
	≥ 9 hrs	≤ 6 hrs	8	2.05	0.87,4.84
	≥ 9 hrs	> 6, < 9 hrs	22	1.80	0.95,3.39
	≥ 9 hrs	≥ 9 hrs	19	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	40	0.90	0.61,1.34
	≤ 6 hrs	> 6, < 9 hrs	19	0.98	0.58,1.66
	≤ 6 hrs	≥ 9 hrs	37	1.48	0.98,2.23
	> 6, < 9 hrs	≤ 6 hrs	75	1.38	0.98,1.93
	> 6, < 9 hrs	> 6, < 9 hrs	220	1.17	0.88,1.54
	> 6, < 9 hrs	≥ 9 hrs	327	1.46	1.12,1.90
	≥ 9 hrs	≤ 6 hrs	8	0.83	0.40,1.73
	≥ 9 hrs	> 6, < 9 hrs	38	1.85	0.77,1.71
	≥ 9 hrs	≥ 9 hrs	71	<i>Referent</i>	
Went to sleep after Midnight⁹					
Yes	≤ 6 hrs	≤ 6 hrs	31	1.33	0.40,4.51
	≤ 6 hrs	> 6, < 9 hrs	12	1.26	0.34,4.65
	≤ 6 hrs	≥ 9 hrs	31	2.88	0.85,9.77
	> 6, < 9 hrs	≤ 6 hrs	9	1.08	0.28,4.13
	> 6, < 9 hrs	> 6, < 9 hrs	13	1.24	0.34,4.47
	> 6, < 9 hrs	≥ 9 hrs	21	2.36	0.67,8.28
	≥ 9 hrs	≤ 6 hrs	7	4.75	1.15,19.7

	≥ 9 hrs	$> 6, < 9$ hrs	2	1.44	0.23,9.02
	≥ 9 hrs	≥ 9 hrs	3	<i>Referent</i>	
No	≤ 6 hrs	≤ 6 hrs	31	1.11	0.72,1.69
	≤ 6 hrs	$> 6, < 9$ hrs	28	1.91	1.21,3.01
	≤ 6 hrs	≥ 9 hrs	17	0.99	0.58,1.68
	$> 6, < 9$ hrs	≤ 6 hrs	97	1.40	1.03,1.91
	$> 6, < 9$ hrs	$> 6, < 9$ hrs	294	1.13	0.87,1.46
	$> 6, < 9$ hrs	≥ 9 hrs	410	1.48	1.16,1.90
	≥ 9 hrs	≤ 6 hrs	6	0.62	0.27,1.40
	≥ 9 hrs	$> 6, < 9$ hrs	55	1.27	0.89,1.80
	≥ 9 hrs	≥ 9 hrs	81	<i>Referent</i>	

1-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep

2-models included grade in school, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

3-models included gender, grade in school, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

4-models included gender, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

5-models included gender, grade in school, live on farm, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

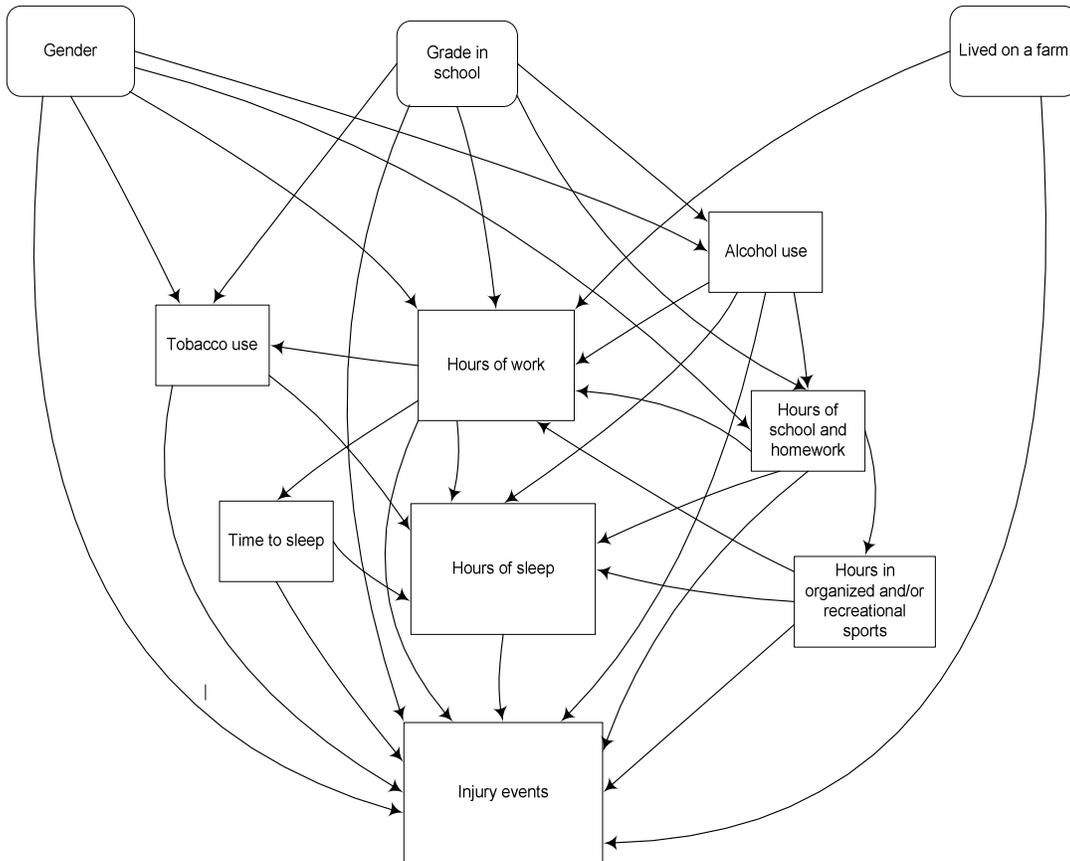
6-model included gender, grade in school, live on farm, smoking status, hours in organized/recreational sports, hours at work, and time to sleep.

7-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours at work, and time to sleep.

8-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and time to sleep.

9-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and hours at work.

Figure 1: Directed Acyclic Graph



**Addendum: Unmeasured Confounder Sensitivity Analysis:
Caffeine use among adolescents**

P_{Z1}	P_{Z0}	OR_{XZ}	OR_{DZ}			
			1	3	5	0.5
			OR_{DX}			
0.8	0.2	16.0	1.30	0.70	0.56	1.95
0.65	0.35	3.45	1.30	0.96	0.87	1.59
0.55	0.45	1.49	1.30	1.18	1.14	1.39
0.35	0.65	0.3	1.30	1.76	1.95	1.06
0.2	0.8	0.1	1.30	2.41	3.03	0.87

P_{Z1} : prevalence of caffeine use among adolescents who reported sleeping less than 9 hours per night

P_{Z0} : prevalence of caffeine use among adolescents who reported sleeping at least 9 hours per night

OR_{XZ} : odds ratio for the association between exposure level and caffeine use

OR_{DZ} : odds ratio for the association between caffeine use and work-related injury

OR_{DX} : odds ratio for the test exposure adjusted for caffeine use

CHAPTER V

RISK OF WORK-RELATED INJURY AMONG SLEEP-DEPRIVED RURAL MINNESOTA ADOLESCENTS

ABSTRACT

The purpose of this study was to determine whether an association exists between work-related injury events and sleep quantity among high school-aged young adults employed during the summer.

Youth at Work, an open cohort from 41 rural high schools in Minnesota, followed 15,002 students from 2001-2003. A total of 22,942 self-completed questionnaires identified events in the summer months, including sleep patterns, employment, and injury experiences. Risk of injury was estimated using sleep patterns from both the usual school night (Sunday through Thursday) and the usual weekend sleep patterns. Adolescents reporting nine or more hours of sleep every night were categorized as referent. Employment was categorized into seven different occupational groups: personal services; restaurant/fast food; retail; professional/medical; construction; entertainment; and farming. Multivariate analyses were conducted using directed acyclic graphs to select confounders.

While controlling for potential confounders, teens employed in entertainment who routinely slept six hours or less or greater than six hours but less than nine hours, had the greatest risk of work-related injury, compared with well-rested teens in this occupation (3.61; 1.17, 11.09). Construction workers who slept either insufficient or sub-optimal hours also were nearly three times as likely to be injured as teens sleeping optimal hours

(2.69; 1.19, 6.06). Among farmers, risk of injury doubled for young adults who had insufficient sleep some nights, but slept optimally other nights (2.05; 1.37, 3.07).

These results indicated that sleep quantity and sleep patterns during the summer may play an important role in the safety of working teens. Findings from this study further enhance the knowledge base relevant to the overall importance of sleep for adolescents, and identified risk factors serve as a basis for further research and consideration of intervention efforts.

BACKGROUND

The sleep patterns of adolescents have generated significant concern in recent years; health concerns, such as obesity, hypertension, diabetes and emotional behaviors, as well as decreased academic achievement, have been linked to decreased sleep duration (Gangwisch *et al.*, 2006; 2007, Hasler *et al.*, 2004, Dahl and Lewis, 2002, Carskadon, 2002,). Adolescence is a time of great developmental change, from physical, psychological, and social perspectives (Richardson and Tate, 2002). One aspect of this change is an alteration in sleep patterns; young adults, compared to preadolescents, appear to undergo a shift in sleep-wake cycles, such that they stay up later in the evening and prefer to sleep later in the morning (Carskadon *et al.*, 1993; Fukuda and Ishihara, 2001). This circadian phase delay is believed to be both biological and environmental in nature. Teen years involve major endocrine alterations, but there are also increased time constraints placed on schedules through school and social commitments and, for many, employment opportunities (Dornbusch, 2002, Giannotti *et al.*, 2002).

The role of employment in adolescent growth and maturation has been debated for decades, but general conclusions indicate that low-intensity employment, that is, less than 20 hours per week, supports educational outcomes, while higher intensity employment may hinder future success (National Research Council, 1998). Employment rates among teenagers enrolled in school, as reported by the Current Population Survey (CPS), peaked in 1998 at 31%, and has steadily declined to 24% in 2007 (Morisi, 2008). The labor force participation rate for youth was 65% in July 2008, about 12 percentage points below its peak for that month in 1989. Between 1989 and 2008, the proportion of

youth enrolled in school in July trended up, and young adults enrolled in school were much less likely than those not enrolled in school to be working (Bureau of Labor Statistics, 2008). Employed adolescents worked fewer hours per week during the school months than during the summer, averaging about 17 hours a week during the school months and 23 hours during the summer months during 1996-1998. Like employment, average hours worked increased with age. During the school months of 1996-1998, employed 15-year-olds worked 12 hours per week, 16-year-olds worked 16 hours, and 17-year-olds worked 18 hours. The summer-month figures were 19, 23, and 25 hours, respectively (United States Department of Labor, 2000).

Among adolescents, work is the fourth leading cause of injury and, by age 17, it is the leading cause (Brooks *et al.*, 1993). Types of injuries commonly incurred by adolescents include lacerations, contusions, abrasions, strains and sprains, fractures, and dislocations (Runyan *et al.*, 2000). Data sources for these injuries are typically emergency department records, industry self-reported data, and youth self-reports; as a result, the true burden and determinants of adolescent injury is not fully understood.

Sleepiness has been identified as a risk factor for work-related injury events among adults, often related to driving (Connor *et al.*, 2001; Lyznicki *et al.*, 1998). Insufficient sleep also has been linked to a 61% increase in injury among rural adults (Choi *et al.*, 2006), and to increased injury risk among adolescents living on farms (Stallones *et al.*, 2006). The risk of multiple injuries was increased more than two-fold among adolescents in China who slept less than seven hours per night compared with those who slept longer (Lam and Yang, 2007). Yet, further study is needed to understand the role of sleep and its association with work-related injury among adolescents.

While research shows that sleep deprivation may be a significant risk to adolescent health, it is unclear how this lack of sleep may impact other aspects of adolescent life, including their safety. The purpose of this study was to determine whether an association exists between sleep duration and work-related injury outcomes among young adults employed during the summer months. This was accomplished by utilizing data from the Youth at Work program that involved a cohort of working adolescents, attending public high schools throughout the rural counties of Minnesota.

METHODS

Overview

This study was based on data from the Youth at Work Program, coordinated by the Minnesota Department of Health (Williams *et al.*, 2004, 2006) Using a stratified cluster design, with agricultural regions as strata and schools as clusters, a sample of 41 rural schools was selected and recruited to participate in the activities of this program. For the current analysis, data from the cohort of 15,002 students, collected through questionnaires administered four times over a two year period, were used. The Institutional Review Board, Human Subjects Committee, at the University of Minnesota approved the protocol for this sub-study analysis; approval for the overall study was obtained from the Institutional Review Board at the Minnesota Department of Health.

Study Population

Data in this study were collected as part of a longitudinal study of work and injuries and illnesses among adolescents enrolled in rural Minnesota high schools. Eligible, for inclusion, were 190 public high schools with at least 20 students in each grade and located in one of 67 Minnesota counties, designated as rural according to United States (U.S.) Department of Agriculture criteria. To achieve a more representative sample of schools and potential agricultural experiences, two additional stratification factors were used in school selection: school size (three categories) and the predominant types of agriculture at the county level (four regions included grain producers, forestry/wild rice, corn/soybeans, and dairy/poultry). Schools within each agricultural region and size category were recruited on a random basis. Four small schools, four

medium schools and two large schools from each of the four agricultural regions and one additional medium school from the most sparsely populated region, to ensure that the sample accurately represented the population, were recruited. In total, 41 (65%) of 63 selected schools agreed to participate, representing a population of 15,368 students in grades 9 through 11.

Participation of schools and students was completely voluntary. Parents were contacted by letter to inform them of the study and allow them the opportunity to have their child opt out of the study. All principals completed online Human Subjects Assurance training from the U.S. Office of Human Research Protection and Federal-wide Assurance of Protection for Human Subjects documentation, as required by the U.S. Department of Health and Human Services.

Data Collection

Data on demographics, work, work hours and hazards, injury, and potential injury risk factors were collected from the entire student body in grades 9-11, through a self-completed questionnaire; this was distributed to each student twice during the 2001-2002 school years, during either class periods or school-wide assemblies at each of the 41 schools. Questionnaire responses identified injury events and exposures in either the summer months (fall administration) or the school year (spring administration). The same questionnaire was administered two additional times during the 2002-2003 school year to the same students and, then in grades 10-12, in the same manner. The open cohort design allowed for students to enter or exit at any time during the two year period; each student received an individual identification number at the beginning of the program or whenever they entered. Completed surveys were scanned and results entered into a database. Data

were then edited for consistency of responses, out-of-range responses, skip patterns, and missing data. For this analysis, only data collected regarding summer activities were utilized.

The open cohort was followed through two school years and the preceding summer months. A total of 15,002 students were surveyed during the four administration cycles of the Youth at Work program; 41,272 eligible questionnaires were completed during these two years; 22,942 of these questionnaires referred to summer activities and were used in this analysis. All four questionnaires were completed by 5,922 students. The original sample of 13,869 students represented an overall response rate of 89% of eligible students in 41 sampled schools. The decrease in participation mainly represented a decline in participating schools (reduced to 35 schools by spring 2003).

Primary Variables in Analysis

For this analysis, the definition used for an injury event was: restriction of normal activities for four hours or more; and/or loss of consciousness, loss or awareness, or amnesia for any length of time; and/or use of professional health care. Injury responses were to a general question stating, "Based on this definition, were you injured?" Further questions assessed the location of the injury event, to determine if the injury was work-related, and if so, in what occupation. The definition for work for this questionnaire encompassed all employment, paid or unpaid, either at home or away from home. These activities included chores or work done for the family, as well as traditional work outside of the home. Adolescents also were asked about the average number of hours of sleep acquired over the questionnaire time frame, both during the week nights (Sunday through Thursday) and the weekend nights (Friday and Saturday). Adolescent activities,

especially work-related, were quite different between the summer months and the school year; thus, for this analysis, only summer employment and associated injury outcomes were assessed.

Data Analysis

Occupations were grouped by Standard Industrial Classification (SIC) codes, and were based on previous research about teen employment in rural communities (Parker *et al.*, 2002). Overall, seven categories were used to describe the occupations: Personal Services included lawn care, babysitting, and housekeeping activities; Restaurant/Fast Food employment consisted of cooks, servers and dishwashers; Retail positions included cashiers, stock clerks and sales clerks; Professional/Medical employment was comprised of positions as varied as office staff, teacher's aides and hospital orderlies; Construction or Manufacturing workers held positions as line workers or laborers; the Entertainment or Recreation industries employed lifeguards, sports instructors, amusement park attendants and dockhands; and finally, Farm work comprised all work done on a farm or agribusiness.

Rates of work-related injury per 1,000 persons were estimated among employed adolescents in each of these seven occupational groups, for both work experience during the summer months. The average of both the usual week night (Sunday through Thursday) sleep patterns and the usual weekend sleep patterns was calculated, and this analysis was stratified by reported sleep hours. Working young adults reporting an average of nine hours of sleep or more were categorized as referent, compared with adolescents who averaged less than nine hours of sleep per night. The relative risk of

work-related injury among sleep-deprived individuals compared with well-rested young adults was calculated.

Multivariate analyses were conducted using directed acyclic graphs (DAGs) to select confounders for each exposure of interest (Greenland *et al.*, 1999; Hernan *et al.*, 2002). The DAGs were based on previous published information, deduction from this information, and previous knowledge of injury mechanisms; also, considered, were data from prior research and information provided by the study advisory group, comprised of teachers, school administrators, public health nurses, safety professionals and injury epidemiologists. Generalized Estimating Equations (GEEs) (Liang and Zeger, 1986) were used to adjust for correlations among multiple observations from the same person. For this analysis, weeknight and weekend night sleep patterns were utilized more fully than in the earlier analysis to address the potential for extreme sleep deprivation and extended sleep being averaged to moderate effects. Sleep patterns were categorized into six groups, with individuals who always reported sleeping nine hours or more every weeknight and weekend night classified as referent. At the other extreme, adolescents who always reported sleeping six hours of sleep or less every night were classified as always having insufficient sleep. The sub-optimal sleep pattern included all individuals who reported always sleeping greater than six hours per night, but less than nine hours. Adolescents who reported different sleep patterns on weeknights than weekend nights make up the final categories: sleeping a fully optimal nine hours or more on either weeknights or weekend nights but sleeping less (either insufficient hours or sub-optimal hours) on other nights; or reporting insufficient sleep on either weeknights or weekend nights but sleeping optimal or sub-optimal hours on other nights.

Sensitivity Analysis

A sensitivity analysis was conducted to assess the magnitude and direction of potential bias from the omission of an unmeasured confounder that increased the odds of adolescent injury by factors of 0.5 and 10. Using methods described by Rothman and Greenland (1998), analyses were conducted to generate a range of estimates for the odds of injury, adjusted for the prevalence of the unmeasured confounder of the use of caffeine and other stimulants among well-rested adolescents versus sleep-deprived adolescents. Caffeine is considered to be the most widely used psychoactive substance. It is believed to be used at least weekly by as much as 98% of the population under 18 years of age, mostly in the form of carbonated beverages (Pollak and Bright, 2003); based on prior research, adolescents reporting high caffeine intake were almost two times more likely to report difficulty sleeping (Roehrs and Roth, 2008).

RESULTS

A total of 15,002 students participated in the Youth at Work program; all responses to the questionnaires were self-reported. The cohort of students in grades 9 through 11 in the first year were followed through one half of their high school career. For this analysis, 22,942 questionnaires were completed, covering the summer months of June through August of 2001 and 2002.

Over two-thirds of the students reported working during the summer survey periods (79% and 70% for the two consecutive summers). Among the students who participated in work, about one-half of them reported working more than eight hours a day during the summer months, and girls reported a higher rate of employment than boys for both survey cycles.

Demographic Characteristics

Characteristics of the study population who reported being employed were analyzed by survey cycle, occupational group, and gender (**Table 1**). Although they made up slightly less than 50% of the working population, boys reported more work-related injuries during the 2001 and 2002 summer months than girls (57% and 53%, respectively). The most commonly reported occupations were in the categories of personal services (which included such jobs as lawn care and babysitting), and farming (family farm or ranch employment and agribusiness). As the student population increased in age, restaurant and retail employment increased for girls (15% to 18% and 10% to 15%, respectively). Employed adolescents reported sleeping more on weeknights, than weekend nights, during the summer. Both boys and girls stated that they slept, on

average, between 9.4 and 10.3 hours per night. Mean hours of sleep on weekend nights, however, was almost two hours less than during the week, at just slightly over eight hours on Friday and Saturday nights.

During the summer, non-farm residents reported being involved in farm work almost as much as farm residents; 9% of non-farm residents and 11% of farm residents listed farming as an occupation during the first summer, and 7% of both reported doing farm work during the second summer. However, farm residents consistently reported more farm-related injuries. During the second summer, nearly 11% of work-related injuries among farm residents were farming-related, while only 4% of injuries reported by non-farm residents were farm-related. Among farm residents, boys reported more injuries than girls.

Older teens, compared with younger teens, reported greater employment and more work-related injuries. During the second summer, students entering their senior year of high school reported 44% of the injuries. Approximately two-thirds of surveyed adolescents worked more than eight hours per day, and these teens reported 80% of the injuries. While 50% of boys and girls participated in sports and recreational activities during the first summer, nearly 60% were no longer involved in these activities, during the second summer; 63% of work-related injuries involved adolescents who were not engaged in sports. Teens who reported that they were current smokers (13%) and drank alcoholic beverages more than five times a month (23%) accounted for a greater percentage of injuries than those who denied participating in these behaviors; almost one-quarter of reported injuries were ascribed to smokers, and drinkers accounted for nearly one-third of all work-related injuries.

Rates and Relative Risk Analyses

Hours of sleep during both weekend nights and week nights were averaged, and occupational injury rates for individuals who slept nine hours or more, those who slept less than nine hours, and the relative risk of injury among sleep-deprived teens are presented in **Table 2**.

During the summer months, the occupational injury rate per 1,000 persons was the lowest among teens employed in retail sales who slept nine hours or more per night, on average (25/1,000), and highest among adolescents employed in farming that averaged less than nine hours per night of sleep (73/1,000). This rate increased to 87/1,000 persons among sleep-deprived youth who resided on a farm, 112/1,000 among sleepy freshman, and 124/1,000 persons who reported not getting enough sleep and smoking. Adolescents involved in construction and manufacturing who smoked also had a high rate of injury, whether they slept nine hours or more, or less than nine hours (102/1,000 persons and 106/1,000 persons, respectively).

Sleep-deprived youth employed in construction and manufacturing had increased risks of injury (Relative Risks [RRs]; 95% Confidence Intervals [Cis]) compared to their well-rested counterparts (2.52; 1.68, 3.79), especially boys (2.21; 1.44, 3.41), farm residents (3.81; 1.32, 11.0), and individuals working in construction more than eight hours per day (2.83; 1.72, 4.63). Adolescents active in farm work were nearly twice as likely to be injured if they slept less than nine hours per night, compared to farm employees who slept nine hours or more (1.91; 1.40, 2.60), especially if they worked more than eight hours per day (1.90; 1.30, 2.78), were not actively involved in sports or

recreational activities for three or more hours per day (2.14; 1.38, 3.31), or if they consumed alcoholic beverages five or more days per month (3.39; 1.55, 7.41).

Employees of restaurants and fast food establishments who slept less than nine hours were 40 percent more likely to be injured at work than well-rested restaurant staff (1.41; 1.08,1.83). Of particular concern were the youngest workers in this occupation, as sleep-deprived freshmen were more than twice as likely to be injured (2.57; 1.11, 5.93).

Multivariate Regression Analyses

Results of multivariate analyses, with further precision by sleep pattern, are presented in **Table 3** with (Odds Ratios [Ors]; and 95% Confidence Intervals [Cis]); key findings are identified below. Based on the directed acyclic graph (**Figure 1**), the variables of grade in school, gender, hours spent at work, hours spent in organized or recreational activities, tobacco use, alcohol use, and residence on a farm, were determined to be potential confounders.

Different sleep patterns emerged as more risky in different occupations. In particular, young adults who reported insufficient sleep of six hours or less during either weekend nights or weeknights, but either sub-optimal (more than six hours but less than nine hours) or optimal sleep during the other nights of the week or weekend, had the greatest risk of occupational injury. When sleep patterns, as well as occupations, are evaluated, the riskiest occupations for Minnesota adolescents were in the entertainment industry and in construction and manufacturing,

While controlling for potential confounders, teens employed in entertainment who routinely slept six hours or less per night or greater than six hours but less than nine hours per night, had the greatest risk of work-related injury, compared with well-rested teens in

this occupation (3.61; 1.17, 11.09). Construction workers who slept either insufficient or sub-optimal hours also were nearly three times as likely to be injured as teens sleeping optimal hours (2.69; 1.19, 6.06). Restaurant employees, construction workers, and adolescents employed in entertainment who always slept six hours or less per night had increased risk of work-related injury (1.92; 1.20, 3.06; 2.34; 1.17, 4.67; and 2.82; 1.06,7.50, respectively). Among farmers, risk of injury doubled for young adults who had insufficient sleep some nights, but slept optimally other nights (2.05; 1.37, 3.07). Adolescents who reported employment in personal services, and also reported always sleeping more than six and less than nine hours every night, had twice the risk of occupational injury (1.90; 1.26, 2.87).

Sensitivity Analysis

To determine the potential effect of an unmeasured confounder upon the results from this study, sensitivity analyses (Rothman and Greenland, 1998) were conducted for caffeine use. From these analyses, it was shown that the magnitude and direction of the effects of sleep on risk of occupational injury among both boys and girls were largely unchanged when accounting for potential sources of study error (see addendum). After adjusting for caffeine intake, under several scenarios, decreased sleep remained a risk factor for work-related injury among both boys and girls in this study. In order to nullify the effect of sleep on injury, the odds ratio for the association between caffeine use and work-related injury would have to be three-fold, with use among sleep-deprived students being twice that of well-rested adolescents.

DISCUSSION

Among teens working during the summer, an increased risk of occupational injury was suggestive for any decrease in sleep quantity below nine hours of sleep per night on average. The occupations of greatest concern were construction and farming. When specific sleep patterns were assessed, insufficient sleep at some time during the week appeared to increase risk, even if optimal sleep was obtained on other nights. Individuals employed in seasonal activities, such as lifeguards and dockhands, who always reported insufficient or sub-optimal sleep, were at the greatest risk of work-related injury compared with adolescents employed in the same profession who slept nine hours or more every night.

Study Strengths and Limitations

Several strengths are important to this study. First, the size of the cohort was critical to this analysis. In total, 15,002 individuals completed almost 23,000 questionnaires during the two summers. The amount of information collected, which included demographics, work experience, and personal behaviors, as well as many other characteristics, allowed for an in-depth analysis.

This analysis was unique in that it did not include small sub-sets of a rural community, such as individuals injured severely enough to require hospitalization, or members of households associated with an agricultural operation, as many studies have. Rather, these data enumerated young adults who lived in rural Minnesota communities and attended public high schools. Thus, the increased injury risk among farm residents,

compared with that of their peers, who had similar schedules and lifestyles, is noteworthy.

Limitations of this study should be considered when interpreting results. One concern is the lack of clear association between sleep per night and an injury event, because data were collected to address average sleep per night rather than exact sleep prior to an injury event. Work hours for this study were reported on a daily basis, but then were averaged over time. This allowed for wide variation, as an individual could work many hours per day for a few days a week, or work several days a week for only a few hours, and still have the same average work hours. Research shows that adolescents working more than 20 hours per week are at increased risk for injury (Carskadon, 1990), emotional distress, cigarette and alcohol use (Resnick *et al.*, 1997), but the schedule by which adolescents worked those hours was not fully examined.

All data were self-reported; thus, it did not afford an opportunity for the research team to validate responses. Results also may reflect the potential for inaccurate recall of injuries, as well as inconsistent recall of sleep hours and sleep patterns (Jenkins *et al.*, 2002; Harel *et al.*, 1994; Langley *et al.*, 1989).

Although schools were randomly selected to participate, some selection bias may have been possible in view of the willingness of the school administration to actively engage in such extracurricular activities. Typically, it was more likely that a school would participate if there had been a recent publicized account of work injury or if the principal or faculty had personal concerns about the work history or injury events among adolescents in the community. Therefore, heightened awareness of the issues of work and injury could have potentially contributed to bias.

Other potential biases include the lack of information on caffeine intake and the role this may have played on sleep quantity among employed adolescents. However a sensitivity analysis showed that this unmeasured confounder would have been unlikely to nullify the study results; it was determined that the magnitude and direction of the effects of sleep on adolescents' risk of work-related injury were largely unchanged when accounting for caffeine use as a potential source of study error.

Conclusions

The findings from this study further enhance the knowledge base relevant to the overall importance of sleep for adolescents, especially adolescents involved in certain occupations. Of concern may be occupations that are often viewed as chores, as adolescents may not have received training to safely perform the tasks related to those positions.

Studies have documented that adolescents do not obtain adequate sleep due to the time constraints of school, activities and work (Carskadon, 2002; Dornbusch, 2002; Graham *et al.*, 2000). Several studies also have addressed the role of sleep and injury among adult occupational cohorts (Gold *et al.*, 1992; Richardson *et al.*, 1989). Results from this study indicated that decreased sleep quantity among working teens may increase risk of work-related injury, especially in certain occupations.

Agricultural operations often share close proximity with rural households, and children and adolescents are exposed to many associated hazards, even if they are not employed by the operation (Gerberich *et al.*, 1993; 2003; 2004, Hard *et al.*, 1999). The increased risk seen among teens employed on ranches or farms, whether residents or not, underscores the importance of intervention in the rural population as a whole.

Sleep is a readily modifiable risk factor for injury among adolescents. The findings from this analysis are important in generating discussion about the overall importance of sleep for adolescents. While health effects from reduced sleep have been well documented recently, the role of sleepiness in the safety of teens must be considered also. Risk factors identified in this study may serve as a basis for further research and consideration of relevant intervention efforts.

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Table 1: Demographic characteristics and occupational injuries by gender among working rural adolescents in Minnesota, 2001-2003

Date Questionnaire Administered	Fall 2001				Fall 2002			
Time Period of Questionnaire	June – August 2001				June – August 2002			
	Total N = 10586	% or SD	Injury N = 850	% or SD	Total N = 6099	% or SD	Injury N = 277	% or SD
Gender								
Boys	5206	49.2	484	56.9	2872	47.1	147	53.1
Personal Services	3239	30.6	111	13.4	1299	21.3	31	11.2
Restaurant	1095	10.3	76	9.1	602	9.9	24	8.7
Retail	933	8.8	33	4.0	563	9.2	13	4.7
Professional/Medical	168	1.6	7	0.8	108	1.8	4	1.4
Entertainment	484	4.6	18	2.2	254	4.2	8	2.9
Construction	1321	12.5	102	12.3	791	13.0	5	1.8
Farming	1379	13.0	125	15.0	769	12.6	32	11.6
Girls	5358	50.6	366	43.1	3226	52.9	130	46.9
Personal Services	4234	40.0	130	15.6	1909	31.3	32	11.6
Restaurant	1543	14.6	102	12.3	1077	17.7	46	16.6
Retail	1097	10.4	22	2.6	893	14.6	14	5.1
Professional/Medical	449	4.2	14	1.7	360	5.9	16	5.8
Entertainment	629	5.9	23	2.8	379	6.2	5	1.8
Construction	192	1.8	11	1.3	112	1.8	30	10.8
Farming	673	6.4	49	5.9	353	5.8	9	3.2
Unknown/Missing	22	0.2	0	0.0	1	0.0	0	0.0
Personal Services	5	0.0	0	0.0	1	0.0	0	0.0
Restaurant	0	0.0	0	0.0	0	0.0	0	0.0
Retail	1	0.0	0	0.0	0	0.0	0	0.0
Professional/Medical	1	0.0	0	0.0	0	0.0	0	0.0
Entertainment	3	0.0	0	0.0	0	0.0	0	0.0
Construction	3	0.0	0	0.0	0	0.0	0	0.0
Farming	1	0.0	0	0.0	0	0.0	0	0.0
Lived on a Farm								
No	8885	83.9	669	78.7	5038	82.6	209	75.5
Boys	4272	48.1	364	54.4	2293	45.5	105	50.2
Girls	4608	51.9	305	45.6	2744	54.5	104	49.8
Unknown/Missing	5	0.1	0	0.0	1	0.0	0	0.0

Yes	1590	15.0	173	20.4	1020	17.4	63	22.7
Boys	872	55.0	113	65.3	553	54.2	42	64.6
Girls	716	45.0	60	34.7	467	45.8	23	35.4
Unknown/Missing	2	0.1	0	0.0	0	0.0	0	0.0
Missing	111	1.0	8	0.9	41	0.7	3	1.1
Boys	62	55.9	7	87.5	26	63.4	0	0.0
Girls	34	30.6	1	12.5	15	36.6	3	100
Unknown/Missing	15	13.5	0	0.0	0	0.0	0	0.0
Grade in School								
Freshman	3171	30.0	262	31.5	0	0.0	0	0.0
Boys	1554	49.0	143	54.6	0	0.0	0	0.0
Girls	1613	50.9	119	45.4	0	0.0	0	0.0
Unknown/Missing	4	0.1	0	0.0	0	0.0	0	0.0
Sophomore	3296	31.1	219	26.4	1881	30.8	74	26.7
Boys	1624	49.3	132	60.3	900	47.8	38	51.3
Girls	1664	50.5	87	39.7	980	52.1	36	48.7
Unknown/Missing	8	0.2	0	0.0	1	0.1	0	0.0
Junior	3876	36.6	351	42.2	2083	34.2	80	28.9
Boys	1920	49.5	200	57.9	938	45.0	39	48.7
Girls	1946	50.2	151	43.0	1145	55.0	41	51.3
Unknown/Missing	10	0.3	0	0.0	0	0.0	0	0.0
Senior	243	2.3	18	2.2	2135	35.0	123	44.4
Boys	108	44.4	9	50.0	1034	48.4	70	56.9
Girls	135	55.6	9	50.0	1101	51.6	53	43.1
Unknown/Missing	0	0.0	0	0.0	0	0.0	0	0.0
Current Smoker								
Yes	1291	12.2	163	19.6	813	13.3	65	23.5
Boys	567	43.9	95	58.3	364	44.8	36	55.4
Girls	723	56.0	68	41.7	449	55.2	29	44.6
Unknown/Missing	1	0.1	0	0.0	0	0.0	0	0.0
No	9042	85.4	672	80.9	5185	85.0	206	74.4
Boys	4505	49.8	376	56.0	2449	47.2	106	51.5
Girls	4531	50.1	296	44.0	2735	52.8	100	48.5
Unknown/Missing	6	0.1	0	0.0	1	0.0	0	0.0
Unknown/Missing	253	2.4	15	1.8	101	1.7	6	2.2
Boys	134	53.0	13	86.7	59	58.4	5	83.3
Girls	104	41.1	2	13.3	42	41.6	1	16.7

Unknown/Missing	15	5.9	0	0.0	0	0.0	0	0.0
Alcohol use >5 days/month								
Yes	1845	17.4	190	22.9	1382	22.7	89	32.1
Boys	951	51.5	134	70.5	712	51.5	58	65.2
Girls	892	48.4	56	29.5	670	48.5	31	34.8
Unknown/Missing	2	0.1	0	0.0	0	0.0	0	0.0
No	8741	82.6	660	79.4	4717	77.3	188	67.9
Boys	4255	48.7	350	53.0	2160	45.8	89	47.3
Girls	4466	51.1	310	47.0	2556	54.2	99	52.7
Unknown/Missing	20	0.2	0.0	0.0	1	0.0	0	0.0
>3 hours/day in Sports								
Yes	5283	49.9	442	53.2	2472	40.5	103	37.2
Boys	2670	50.5	256	57.9	1208	48.9	56	54.3
Girls	2608	49.4	186	42.1	1263	51.1	47	45.6
Unknown/Missing	5	0.1	0	0.0	1	0.0	0	0.0
No	5303	50.1	408	49.1	3627	59.5	174	62.8
Boys	2536	47.8	228	55.9	1664	45.0	91	52.3
Girls	2750	51.9	180	44.1	1963	54.1	83	47.7
Unknown/Missing	17	0.3	0	0.0	0	0.0	0	0.0
>4 hrs/day in School/doing Homework								
Yes	150	1.4	20	2.4	64	1.0	7	2.5
Boys	86	57.3	11	55.0	45	70.3	5	71.4
Girls	63	42.0	9	45.0	19	29.7	2	28.6
Unknown/Missing	1	0.7	0	0.0	0	0.0	0	0.0
No	10436	98.6	830	99.9	6035	99.0	270	97.5
Boys	5120	49.1	473	57.0	2827	46.8	142	52.6
Girls	5295	50.7	357	43.0	3207	53.1	128	47.4
Unknown/Missing	21	0.2	0	0.0	1	0.0	0	0.0
>8 hours/day at work								
Yes	6885	65.0	666	80.1	4143	67.9	226	81.6
Boys	3235	53.0	371	55.7	1913	46.2	115	50.9
Girls	3648	47.0	295	44.3	2229	53.8	111	49.1
Unknown/Missing	2	0.0	0	0.0	1	0.0	0	0.0
No	3701	35.0	184	22.1	1956	32.1	51	18.4
Boys	1971	53.3	113	61.4	959	49.0	32	62.8

Girls	1710	46.2	71	38.6	997	51.0	19	37.3
Unknown/Missing	20	0.5	0	0.0	0	0.0	0	0.0
Mean hours of sleep on week nights								
Mean	10.0	4.8	9.5	4.7	9.6	4.8	9.1	4.8
Boys	9.8	4.7	9.4	4.8	9.4	4.7	9.2	5.1
Girls	10.3	4.9	9.6	4.7	9.8	4.9	8.9	4.4
Unknown/Missing	9.6	7.1	0	0.0	12.0	0	0	0.0
Mean hours of sleep on weekends								
Mean	8.3	2.2	8.0	2.4	8.1	2.2	7.4	2.5
Boys	8.3	2.3	8.0	2.4	8.0	2.3	7.3	2.6
Girls	8.4	2.1	8.0	2.4	8.2	2.1	7.6	2.8
Unknown/Missing	7.3	2.2	0	0.0	11.0	0	0	0.0
Went to Sleep after Midnight								
Yes	3024	28.6	246	29.6	1731	28.4	79	28.5
Boys	1417	46.8	126	51.2	743	42.9	36	45.6
Girls	1605	53.1	120	48.8	988	57.1	43	54.4
Unknown/Missing	2	0.1	0	0.0	0	0.0	0	0.0
No	5476	51.7	454	54.6	3073	50.4	137	49.5
Boys	2809	51.3	272	59.9	1526	49.7	79	57.7
Girls	2664	48.7	182	40.1	1546	50.3	58	42.3
Unknown/Missing	3	0.1	0	0.0	1	0.0	0	0.0
Missing/Unknown	2086	19.7	150	18.1	1295	21.2	61	22.0
Boys	980	47.0	86	57.3	603	46.6	32	52.5
Girls	1089	52.2	64	42.7	692	53.4	29	47.5
Unknown/Missing	17	0.8	0	0.0	0	0.0	0	0.0

Table 2: Occupational Injury Rate/1,000 persons and relative risk among well-rested and sleep-deprived employed Minnesota adolescents during the summer months, 2001-2002

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/ 1,000 persons	95% CI	N Injuries	Rate/ 1,000 persons	95% CI		
Overall Rate								
Personal services	170	28.2	24.2,32.7	99	21.1	17.3,25.7	1.27	1.01,1.61
Restaurant/Fast food	159	62.2	53.4,72.4	78	44.2	35.5,55.0	1.41	1.08,1.83
Retail sales	54	25.2	19.3,32.9	25	18.9	12.8,27.9	1.62	1.01,2.60
Professional/Medical	24	34.6	23.4,51.0	11	28.8	16.1,51.1	1.34	0.70,2.54
Construction	113	64.2	53.5,76.9	31	45.6	32.0,64.6	2.52	1.68,3.79
Entertainment	33	29.9	21.2,42.1	13	19.6	11.4,33.3	1.64	0.92,2.93
Farming	154	72.6	62.0,84.8	51	47.8	36.3,62.9	1.91	1.40,2.60
Gender								
Girls								
Personal services	101	30.3	25.0,36.8	51	17.8	13.4,23.5	1.63	1.17,2.26
Restaurant/Fast food	93	60.6	49.6,73.9	48	44.1	33.3,58.3	1.49	1.07,2.09
Retail sales	23	19.2	12.6,29.1	11	14.2	7.9,25.4	1.98	0.93,4.23
Professional/Medical	19	37.3	24.0,57.4	9	31.5	16.5,59.0	1.39	0.66,2.93
Construction	12	62.5	36.0,106.4	4	36.7	13.8,93.7	2.42	0.78,7.51
Entertainment	17	26.9	16.8,42.8	8	21.0	10.6,41.3	1.71	0.77,3.77
Farming	38	63.2	46.3,85.7	16	38.8	23.9,62.4	1.95	1.11,3.42
Boys								
Personal services	69	25.5	20.1,32.5	48	26.1	19.7,34.5	0.98	0.70,1.37
Restaurant/Fast food	66	64.7	51.1,81.6	30	44.3	31.2,62.7	1.37	0.90,2.09
Retail sales	31	33.1	23.3,46.6	14	25.8	15.3,43.0	1.35	0.73,2.49
Professional/Medical	5	27.3	24.0,57.4	2	20.8	5.2,79.5	1.57	0.42,5.90
Construction	101	64.4	53.1,78.0	27	47.4	32.4,68.8	2.21	1.44,3.41
Entertainment	16	34.3	20.5,56.9	5	17.8	7.4,41.8	1.66	0.70,3.94

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/1,000 persons	95% CI	N Injuries	Rate/1,000 persons	95% CI		
Farming	116	76.4	63.6,91.5	35	53.9	38.4,75.1	1.68	1.17,2.42
Live on a Farm								
Yes								
Personal services	18	18.9	11.9,29.7	8	13.1	6.5,26.1	1.35	0.63,2.89
Restaurant/Fast food	8	31.6	15.9,61.7	2	15.8	4.0,60.6	3.04	0.68,13.5
Retail sales	4	17.3	6.6,45.0	2	19.2	4.8,73.7	1.26	0.25,6.48
Professional/Medical	7	58.3	28.1,117.3	1	26.8	3.7,169.3	1.77	0.37,8.49
Construction	28	78.8	54.0,113.6	4	36.5	13.8,93.0	3.81	1.32,11.0
Entertainment	5	31.4	13.2,72.7	2	25.6	6.4,97.1	1.52	0.31,7.51
Farming	107	87.3	72.3,105.1	29	50.8	35.2,72.8	1.77	1.19,2.64
No								
Personal services	150	29.9	25.4,35.1	91	22.5	18.3,27.7	1.27	0.99,1.63
Restaurant/Fast food	150	65.6	56.1,76.6	75	46.3	37.0,57.7	1.42	1.09,1.86
Retail sales	49	25.9	19.5,34.2	23	19.0	12.7,28.4	1.65	1.00,2.70
Professional/Medical	16	28.4	17.5,45.7	10	29.2	15.9,53.3	1.17	0.57,2.40
Construction	84	60.5	49.0,74.5	26	45.8	31.3,66.5	2.39	1.54,3.71
Entertainment	28	29.9	20.5,43.5	11	19.0	10.6,33.8	1.69	0.91,3.16
Farming	46	52.4	39.1,69.7	21	43.6	28.6,65.9	1.47	0.90,2.39
Grade in School								
Freshman								
Personal services	55	46.7	36.0,60.4	45	30.0	22.5,40.0	1.41	0.96,2.06
Restaurant/Fast food	15	67.8	41.5,108.7	7	25.8	12.3,53.1	2.57	1.11,5.93
Retail sales	3	23.4	7.9,67.1	5	41.0	17.2,94.7	0.72	0.17,3.03
Professional/Medical	1	15.1	2.1,100.3	3	46.4	14.9,135.5	0.30	0.03,2.70
Construction	17	79.6	50.1,124.1	13	72.8	43.5,119.5	1.58	0.77,3.24
Entertainment	4	35.3	13.6,88.8	3	20.9	6.7,63.0	1.41	0.47,4.18

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/ 1,000 persons	95% CI	N Injuries	Rate/ 1,000 persons	95% CI		
Farming	43	112.0	84.6,146.9	26	78.1	54.0,111.7	1.86	1.16,2.97
Sophomore								
Personal services	48	25.2	19.1,33.3	27	15.9	11.0,23.0	1.69	1.09,2.63
Restaurant/Fast food	29	40.5	28.3,57.8	23	37.7	25.2,56.1	1.01	0.60,1.72
Retail sales	9	20.0	10.5,37.5	5	15.2	6.3,35.9	1.86	0.65,5.35
Professional/Medical	2	16.0	4.2,59.3	3	30.0	10.2,85.1	1.13	0.25,5.03
Construction	25	57.4	39.1,83.6	8	30.6	15.0,61.6	2.75	1.25,6.06
Entertainment	13	40.7	23.8,69.0	3	14.7	4.8,44.4	3.95	1.14,13.7
Farming	48	75.0	57.3,97.7	13	29.7	17.4,50.2	3.19	1.73,5.86
Junior								
Personal services	53	24.7	18.9,32.2	22	18.7	12.4,28.2	1.46	0.92,2.31
Restaurant/Fast food	89	75.5	61.7,92.0	42	61.0	45.4,81.5	1.15	0.80,1.65
Retail sales	28	26.7	18.6,38.3	12	18.4	10.5,32.1	1.27	0.65,2.49
Professional/Medical	11	35.1	19.5,62.3	2	13.7	3.7,49.9	1.99	0.56,7.13
Construction	51	68.3	52.0,89.2	8	46.4	24.1,87.7	3.55	1.69,7.46
Entertainment	12	25.9	14.4,45.9	6	24.0	11.0,51.6	1.09	0.41,2.89
Farming	51	65.5	49.8,85.6	8	38.1	19.5,73.1	2.63	1.38,5.03
Senior								
Personal services	14	17.0	9.9,29.1	5	15.4	6.0,39.3	1.21	0.45,3.26
Restaurant/Fast food	26	59.2	40.6,85.5	6	30.8	14.0,66.5	1.66	0.69,3.98
Retail sales	14	27.3	16.5,45.0	3	13.9	4.5,42.2	1.77	0.52,6.11
Professional/Medical	10	53.1	28.9,95.7	3	45.0	14.4,132.0	0.98	0.31,3.05
Construction	20	54.4	34.7,84.1	2	29.6	8.7,95.8	3.90	0.92,16.6
Entertainment	4	19.0	6.7,52.9	1	15.3	2.2,96.9	1.77	0.21,15.2
Farming	12	34.7	19.0,62.7	4	43.7	12.1,146.0	1.24	0.41,3.76
Current Smoker								

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/ 1,000 persons	95% CI	N Injuries	Rate/ 1,000 persons	95% CI		
Yes								
Personal services	37	46.3	33.6,63.4	17	41.4	26.0,65.4	1.19	0.70,2.05
Restaurant/Fast food	38	75.9	55.4,103.2	20	78.7	51.3,119.0	0.95	0.57,1.60
Retail sales	12	35.1	19.9,61.2	5	30.1	12.6,70.4	1.42	0.42,4.75
Professional/Medical	8	60.7	30.7,116.3	2	37.1	10.0,127.8	1.13	0.35,3.65
Construction	28	106.1	74.1,149.6	8	102.0	52.4,189.0	1.75	0.80,3.83
Entertainment	4	30.4	10.0,88.5	1	20.7	2.9,133.8	2.51	0.29,21.4
Farming	29	124.4	86.4,175.8	5	67.9	26.4,163.6	2.07	0.90,4.77
No								
Personal services	131	25.6	21.5,30.4	81	19.2	15.4,23.9	1.26	0.97,1.63
Restaurant/Fast food	119	59.5	49.9,70.7	58	39.0	30.2,50.3	1.48	1.09,2.00
Retail sales	41	23.4	17.2,31.8	19	16.7	10.7,26.1	1.66	0.96,2.87
Professional/Medical	16	29.1	18.0,46.8	9	28.0	14.7,52.5	1.31	0.61,2.84
Construction	84	58.1	47.0,71.5	23	38.8	25.7,58.1	2.69	1.68,4.32
Entertainment	29	30.4	21.0,43.8	12	20.0	11.4,34.8	1.61	0.88,2.95
Farming	119	65.0	54.4,77.5	44	45.3	33.5,61.0	1.89	1.34,2.66
Alcohol use >5 days/month								
Yes								
Personal services	40	32.8	24.2,44.4	14	23.3	13.9,38.9	1.54	0.87,2.72
Restaurant/Fast food	48	77.4	59.0,101.0	18	51.9	32.7,81.4	1.27	0.76,2.13
Retail sales	10	20.1	10.9,36.8	6	22.4	11.5,28.1	0.80	0.29,2.20
Professional/Medical	10	55.8	30.3,100.4	3	43.6	14.3,125.0	1.32	0.42,4.14
Construction	71	76.9	57.2,102.7	7	54.7	23.9,120.5	2.85	1.29,6.29
Entertainment	6	28.7	13.2,61.2	1	11.7	1.8,74.0	3.37	0.42,27.4
Farming	50	91.1	68.5,120.2	6	40.2	17.2,91.2	3.39	1.55,7.41

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/ 1,000 persons	95% CI	N Injuries	Rate/ 1,000 persons	95% CI		
No								
Personal services	130	27.0	22.7,32.1	85	20.8	16.7,25.7	1.21	0.94,1.57
Restaurant/Fast food	111	57.3	47.7,68.8	60	42.3	32.9,54.3	1.38	1.01,1.87
Retail sales	44	26.8	19.9,36.0	19	18.1	10.1,48.9	1.88	1.10,3.21
Professional/Medical	14	27.3	16.3,45.3	8	25.6	12.9,50.2	1.20	0.55,2.65
Construction	42	58.6	46.4,73.6	24	43.5	29.2,64.5	2.29	1.42,3.67
Entertainment	27	30.2	20.6,44.1	12	20.7	11.8,36.1	1.55	0.84,2.85
Farming	104	66.3	55.0,79.8	45	49.1	36.5,65.8	1.63	1.16,2.30
>3 hours/day in Sports								
Yes								
Personal services	96	32.7	26.8,39.8	50	21.6	16.4,28.4	1.43	1.04,1.97
Restaurant/Fast food	68	57.8	45.8,72.5	43	54.3	40.3,72.8	1.13	0.78,1.63
Retail sales	20	20.8	13.5,31.8	8	14.2	7.1,28.1	1.77	0.78,4.02
Professional/Medical	7	21.4	10.3,44.1	6	34.5	15.7,73.8	0.81	0.29,2.23
Construction	53	66.1	50.7,85.7	22	60.3	39.1,92.0	1.74	1.06,2.87
Entertainment	17	26.5	16.5,42.2	7	18.8	9.1,38.5	1.42	0.64,3.16
Farming	70	68.4	54.2,86.0	28	52.1	36.0,74.9	1.70	1.10,2.61
No								
Personal services	74	23.9	19.0,29.9	49	20.6	15.5,27.2	1.11	0.79,1.58
Restaurant/Fast food	91	66.1	54.0,80.7	35	36.0	26.0,49.7	1.78	1.21,2.61
Retail sales	34	28.8	20.5,40.3	17	22.5	14.0,35.9	1.42	0.81,2.52
Professional/Medical	17	46.4	29.2,73.1	5	24.1	10.3,55.2	1.84	0.77,4.38
Construction	60	62.6	48.6,80.3	9	29.1	15.4,54.4	4.37	2.22,8.61
Entertainment	16	34.9	21.7,55.8	6	20.6	9.3,45.1	1.94	0.82,4.58
Farming	84	76.4	62.0,93.7	23	43.4	28.8,64.9	2.14	1.38,3.31

Characteristics	< 9 hours sleep			≥ 9 hours sleep			Relative Risk	95% CI
	N Injuries	Rate/1,000 persons	95% CI	N Injuries	Rate/1,000 persons	95% CI		
> 8 hours/day at Work								
Yes								
Personal services	128	28.4	23.8,33.7	68	23.8	18.7,30.2	1.03	0.77,1.39
Restaurant/Fast food	132	65.2	55.1,76.9	56	45.5	35.2,58.7	1.44	1.03,2.02
Retail sales	47	26.3	19.7,34.9	23	22.6	15.0,33.7	1.68	0.92,3.08
Professional/Medical	23	41.0	27.5,60.8	10	35.8	19.5,64.9	1.32	0.58,3.01
Construction	106	68.2	56.5,82.1	25	47.2	31.9,69.3	2.83	1.72,4.63
Entertainment	26	31.3	21.0,46.6	8	17.8	9.0,35.0	1.68	0.80,3.53
Farming	129	74.5	62.8,88.3	35	46.6	33.5,64.5	1.90	1.30,2.78
No								
Personal services	42	27.6	20.5,37.2	31	16.9	11.9,23.9	1.61	1.10,2.36
Restaurant/Fast food	27	51.1	35.2,73.6	22	41.2	27.3,61.8	1.17	0.76,1.80
Retail sales	7	19.9	9.7,40.5	2	6.7	1.7,26.3	1.20	0.55,2.62
Professional/Medical	1	7.4	1.0,52.3	1	9.6	1.3,65.6	1.19	0.41,3.43
Construction	7	34.6	16.3,72.0	6	40.2	18.9,83.4	1.49	0.73,3.04
Entertainment	7	25.8	12.3,53.6	5	23.3	9.7,54.8	1.40	0.55,3.62
Farming	25	63.9	43.2,93.5	16	50.7	31.4,80.9	1.49	0.86,2.58

Table 3: Odds ratios and 95% confidence intervals for reduced sleep as a risk factor for work-related injury among Minnesota Adolescents, by occupation, 2001-2003

Occupation	Sleep Hours Reported during Weeknights and Weekend Nights (hours per night); (hours per night)	Injury N	Odds Ratio	95% CI
Personal Services*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	26	1.58	1.00,2.49
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	37	1.90	1.26,2.87
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	17	1.86	1.08,3.21
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	64	1.03	0.74,1.44
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	62	1.06	0.76,1.46
	<i>Always optimal sleep (≥ 9 hrs/night); (≥ 9 hrs/night)</i>	85	<i>Referent</i>	<i>Referent</i>
Restaurant/ Fast Food*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	30	1.92	1.20,3.06
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	25	1.36	0.83,2.24
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	11	1.43	0.75,2.73
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	58	1.08	0.75,1.55
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	50	1.00	0.69,1.47
	<i>Always optimal sleep (≥ 9 hrs/night); (≥ 9 hrs/night)</i>	63	<i>Referent</i>	<i>Referent</i>

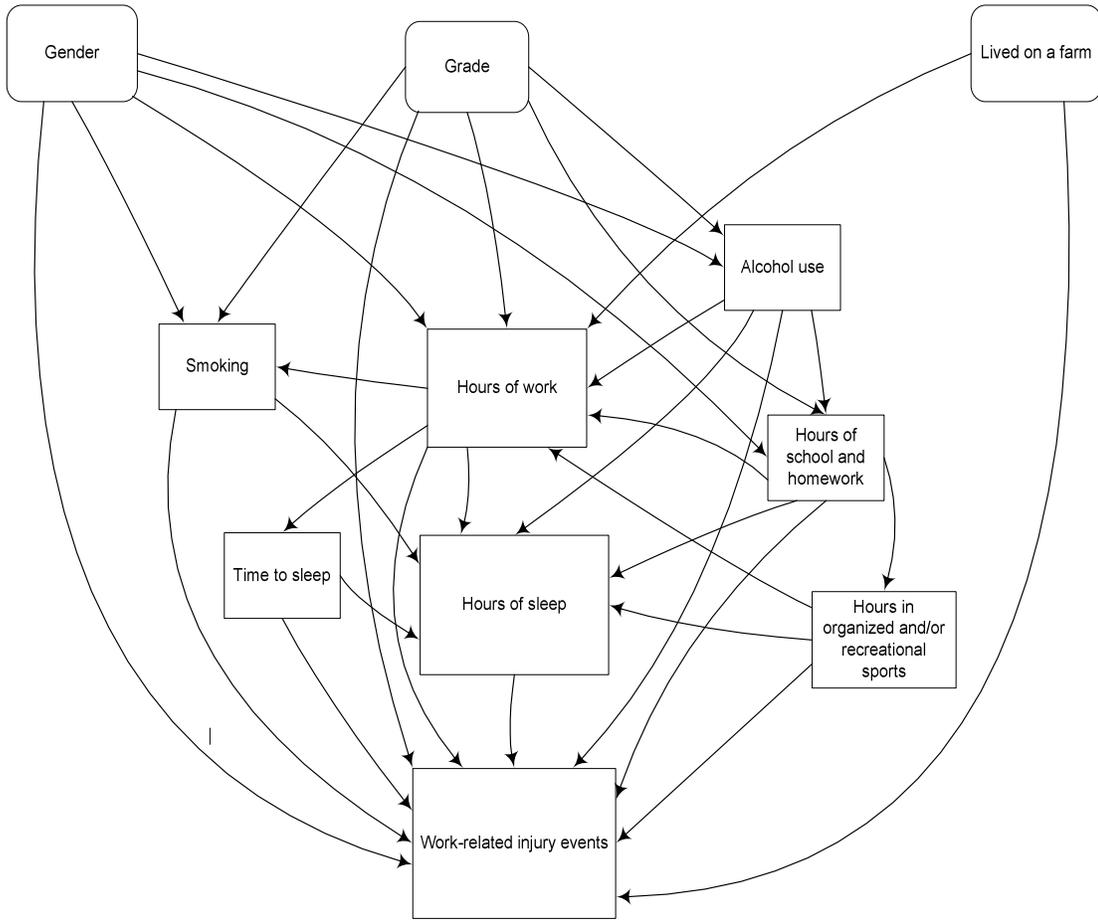
Occupation	Sleep Hours Reported during Weeknights and Weekend Nights (hours per night); (hours per night)	Injury N	Odds Ratio	95% CI
Retail Sales*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	7	1.42	0.57,3.51
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	5	0.89	0.31,2.40
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	1	0.44	0.06,3.17
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	29	1.67	0.89,3.12
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	17	1.14	0.58,2.24
	<i>Always optimal sleep (≥ 9 hrs/night); (≥ 9 hrs/night)</i>	18	<i>Referent</i>	<i>Referent</i>
Professional /Medical*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	1	0.25	0.03,1.96
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	4	0.87	0.29,2.57
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	2	1.02	0.23,4.42
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	11	0.86	0.39,1.89
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	7	0.65	0.26,1.61
	<i>Always optimal sleep (≥ 9 hrs/night); (≥ 9 hrs/night)</i>	13	<i>Referent</i>	<i>Referent</i>
Construction*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	17	2.34	1.17,4.67
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	11	1.28	0.59,2.76

Occupation	Sleep Hours Reported during Weeknights and Weekend Nights (hours per night); (hours per night)	Injury N	Odds Ratio	95% CI
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	9	2.69	1.19,6.06
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	58	2.58	1.55,4.29
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	28	1.58	0.90,2.77
	<i>Always optimal sleep</i> (≥ 9 hrs/night); (≥ 9 hrs/night)	21	<i>Referent</i>	<i>Referent</i>
Entertainment*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	6	2.82	1.06,7.50
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	5	1.92	0.65,5.68
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	4	3.61	1.17,11.09
	Either insufficient sleep or optimal sleep (≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)	13	1.36	0.60,3.12
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	14	1.65	0.77,3.53
	<i>Always optimal sleep</i> (≥ 9 hrs/night); (≥ 9 hrs/night)	12	<i>Referent</i>	<i>Referent</i>
Farming*				
	Always insufficient sleep (≤ 6 hrs/night); (≤ 6 hrs/night)	19	1.60	0.89,2.88
	Always sub-optimal sleep ($>6, <9$ hrs/night); ($>6, <9$ hrs/night)	16	1.20	0.62,2.32
	Either insufficient sleep or sub-optimal sleep (≤ 6 hrs/night); ($>6, <9$ hrs/night), or ($>6, <9$ hrs/night); (≤ 6 hrs/night)	6	1.15	0.47,2.82
	Either insufficient sleep or optimal sleep	89	2.05	1.37,3.07

Occupation	Sleep Hours Reported during Weeknights and Weekend Nights (hours per night); (hours per night)	Injury N	Odds Ratio	95% CI
	(≤ 6 hrs/night); (≥ 9 hrs/night) or (≥ 9 hrs/night); (≤ 6 hrs/night)			
	Either optimal sleep or sub-optimal sleep (≥ 9 hrs); ($>6, <9$ hrs/night) or ($>6, <9$ hrs/night); (≥ 9 hrs)	35	1.17	0.72, 1.89
	<i>Always optimal sleep</i> (≥ 9 hrs/night); (≥ 9 hrs/night)	39	<i>Referent</i>	<i>Referent</i>

*: models included gender, grade in school, live on farm, current smoking status, alcohol consumption, hours in organized/recreational sports and hours at work

Figure 1: Directed Acyclic Graph



ADDENDUM

ADDENDUM: Unmeasured Confounder Sensitivity Analysis: Caffeine use among adolescents, by gender

P _{Z1}	P _{Z0}	OR _{XZ}	OR _{DZ}			
			1	3	5	0.5
			OR _{DX}			
GIRLS						
0.7	0.3	5.44	1.50	1.00	0.87	1.96
0.65	0.35	3.45	1.50	1.11	1.00	1.83
0.55	0.45	1.49	1.50	1.36	1.31	1.60
0.35	0.65	0.29	1.50	2.03	2.25	1.23
0.2	0.8	0.06	1.50	2.79	3.50	1.00
BOYS						
0.7	0.3	5.44	1.30	0.87	0.75	1.70
0.65	0.35	3.45	1.30	0.96	0.87	1.59
0.55	0.45	1.49	1.30	1.18	1.14	1.39
0.35	0.65	0.29	1.30	1.76	1.95	1.06
0.2	0.8	0.06	1.30	2.41	3.03	0.87

P_{Z1}: prevalence of caffeine use among girls who reported sleeping less than 9 hours per night

P_{Z0}: prevalence of caffeine use among girls who reported sleeping at least 9 hours per night

OR_{XZ}: odds ratio for the association between exposure level and caffeine use

OR_{DZ}: odds ratio for the association between caffeine use and work-related injury

OR_{DX}: odds ratio for the test exposure adjusted for caffeine use

CHAPTER VI

DISCUSSION

Overview

This goal of this study was to examine the role of sleep as a potential risk factor for injury, in general, and, specifically, work-related injury among adolescents in rural communities. Multivariate analyses were used to assess associations between sleep patterns, factors related to reduced sleep, and all types of injuries, using a unique database from a cohort of rural high school students. These factors also were considered among the working population of the cohort, addressing different occupations pursued by teens, and the outcome of occupational injuries.

This study is important, because, while several studies have addressed possible health factors related to a reduction in sleep duration, few have identified the magnitude and impact of accumulated sleep debt on the safety of this vulnerable population. As presented in earlier chapters, it is generally believed that humans need one hour of sleep for every two hours of wakefulness, (Dement, 1999), and at no time in human development is this more important than in adolescence, when more than nine hours per night is a preferred sleep duration (Carskadon, 2002, Graham *et al.*, 2000). Although it has been clear for more than three decades that high school students obtained inadequate sleep, research linking short sleep duration with health concerns in adolescents began when adolescent sleep and waking behaviors were associated with daytime sleepiness, depressive moods, and poorer academic performance (Wolfson and Carskadon, 1998; Dahl *et al.*, 2002). Work-related injury also poses as a major concern for adolescents, as work is a leading cause of injury among teens (Brooks *et al.*, 1993). Increased sleep

deprivation among adolescents impacts their physical health, emotional health, risk of injury, and represents a significant public health concern.

Research linking sleepiness as a risk factor for injury events gained momentum when drowsiness was identified as a principal reason behind many catastrophic industrial and auto-related events (Mitler *et al.*, 1988; Connor *et al.*, 2001; Lyznicki *et al.*, 1998). While some factors relating sleep and injury have been more fully described, there is limited knowledge on the role played in adolescence. Thus, the aims of this research were to shed more light on this area through an in-depth examination of sleep patterns and sleep duration among adolescents in rural Minnesota, including a sub-sample of working adolescents, relevant to the effect on injury occurrence in this population.

Aim 1: Sleep patterns and risk of injury among rural Minnesota adolescents

Factors influencing sleep patterns among adolescents include biological, behavioral, and social parameters. These parameters also may play a role in risk of injury. Sleep characteristics reported as potential injury risk factors include: (1) sleepiness or drowsiness (Leger, 1994; Connor *et al.*, 2001; Lyznicki *et al.*, 1998; Hakkanen and Summala, 2000); (2) sleep apnea, or poor sleep quality (Terán-Santos *et al.*, 1999; Spengler *et al.*, 2004; Choi *et al.*, 2006); (3) sleep quantity or sleep duration (Valent *et al.*, 2001; Lombardi *et al.*, 2004; Stallones *et al.*, 2006; Choi *et al.*, 2006; Gabel and Gerberich, 2002; Lam and Yang, 2007; Koulouglioti *et al.*, 2008); and (4) disruption in circadian patterns due to shift work (Richardson *et al.*, 1989; Gold *et al.*, 1992; Smith *et al.*, 1994; Gianotti *et al.*, 2002). Several studies have documented that adolescents do not obtain adequate sleep (Valdez *et al.*, 1996; Fukuda and Ishihara, 2001; Tagaya *et al.*,

2004; Yang *et al.*, 2005; Ghanizadeh *et al.*, 2008). Additionally, in one study, girls reported worse sleep quality than boys (Giannotti and Cortesi, 2002).

Results from the current study indicate that sleep may play an important role in the safety of adolescents. An increased risk of injury was found for any decrease in sleep hours, compared with the minimum of nine hours per night that is suggested for teens (Graham *et al.*, 2000). Additionally, changes in week-night, versus weekend, sleep schedules appeared to play a role in risk of injury.

One of the notable findings was the increased risk of injury among girls who experienced sleep loss during the summer months, compared with well-rested females. Although this pattern did not carry over into the school year, further research is needed to assess the role of sleep among adolescent girls. While boys typically have an increased risk of injury, compared with girls, sleep did not appear to be as important a risk factor among boys during the summer. Sleep deprivation did not significantly increase risk among this population when compared with young men who slept a full nine hours per night. During the school year, however, boys who slept optimally on weekend nights but less during the school nights had an increased risk of injury.

Another important conclusion from this analysis was the increased risk of injury among sleep-deprived farm residents. Agricultural operations often share close proximity with rural households, and children and adolescents are exposed to many associated hazards, such as large equipment, animals, and work environments, even if they are not employed by the operation (Gerberich *et al.*, 2003; Gerberich *et al.*, 2004; Hard *et al.*, 1999; Gerberich *et al.*, 1993). However, the role of sleepiness among adolescent farmers, especially during the school months, may further increase these inherent risks. This

increased risk seen among farm residents underscores the importance of intervention in this vulnerable population.

There appeared to be an increased risk of injury among employed adolescents who slept less than optimal hours, compared with well-rested adolescents. During the summer months, risk was increased among working teens who slept less on weekend nights and, during the school months, risk was increased among young workers who slept less on school nights. Several studies have addressed the role of sleep and injury among occupational cohorts; shift workers, in particular, are believed to be chronically deprived of sleep, regular meal times, and other elements essential to the circadian clock (Gold *et al.*, 1992; Richardson *et al.*, 1989). Similar to findings from these adult studies, it appeared that sleeping optimal hours for a few nights a week to account for accumulated sleep debt did not diminish the risk of injury for students.

Ideally, it would appear that students should maintain a consistent sleep pattern throughout the week to decrease their risk of injury. Injury risk associated with reduced sleep, whether during weeknights or weekend nights, may have a seasonal component. During the summer months, an increased risk of injury was associated with decreased sleep during weekend nights while, during the school year, decreased sleep during school nights was a greater risk factor for injury.

The findings from this analysis are important in generating discussion about the overall importance of sleep for adolescents. While health effects from reduced sleep have been well documented recently, the role of sleepiness in the safety of teens must be considered also. Risk factors identified in this study may serve as a basis for further

research and consideration of relevant intervention efforts, both during the school year and during summer months.

Study Strengths and Limitations

Several strengths are important to this study. First, the size of the cohort was critical to this analysis. In total, 15,002 individuals completed almost 42,000 questionnaires over a two-year period.

This analysis was unique in that it did not include small sub-sets of a rural community, such as individuals injured severely enough to require hospitalization, or members of households associated with an agricultural operation, as many studies have. Rather, these data enumerated young adults who lived in rural Minnesota communities and attended public high schools. Thus, the increased injury risk among farm residents, compared with that of their peers, who had similar schedules and lifestyles, is noteworthy.

While this study addressed an important deficiency in the current knowledge about sleep patterns and risk of injury among adolescents, limitations of this study should be considered when interpreting results. One concern is the lack of clear association between sleep per night and an injury event, because data were collected to address average sleep per night rather than exact sleep prior to an injury event. It is anticipated that there is a potential for measurement error in the reporting of both injury events and associated exposures for these events, due to the self-reported nature of the information, the time-dependent memory decay, and the nature of the participants. All data were self-reported; thus, there was no opportunity for the research team to validate responses. Results also may reflect the potential for inaccurate recall of injuries, especially during

the nine-month school year, as well as inconsistent recall of sleep hours and sleep patterns (Jenkins *et al.*, 2002; Harel *et al.*, 1994; Langley *et al.*, 1989).

Schools were randomly selected to participate; but, some bias may be anticipated which reflected the willingness of the school administration to actively engage in such extracurricular activities. Typically, it was more likely that a school would participate if there had been a recent publicized account of work injury or if the principal or faculty had personal concerns about the work history or injury events among adolescents in the community. Therefore, this bias could potentially contribute to heightened awareness of the issues of work and injury and increased reporting.

Although the study population decreased from the 13,869 students at the start of the 2001-2002 school year to 7,802 students by the end of the 2002-2003 school year, the characteristics of the student population and the effect of sleep patterns and sleep quantity remained constant. The only exception to this could be seen in the senior class, and this result was primarily due to the sparse number of seniors who participated in the first year. In total, 5,618 students completed all four questionnaire cycles, and an additional 2,128 students completed three of the four questionnaires. Thus, despite the attrition in this study, results did not appear to be affected.

While there is always a potential for bias due to unmeasured confounders, sensitivity analyses were conducted to determine the potential effect of such a confounder upon the results identified in this study. From these analyses, it was determined that the magnitude and direction of the effects of sleep on adolescents' risk of injury were largely unchanged when accounting for potential sources of study error.

Despite these limitations, the findings from this analysis are useful in generating discussion about the overall importance of sleep for adolescents. Risk factors identified in this study may serve as a basis for further research and consideration of relevant intervention efforts.

Aim 2: Risk of work-related injuries among sleep-deprived rural Minnesota adolescents

Sleep quantity has been linked to an increased risk of occupational injury (Lombardi *et al.*, 2004; Gabel and Gerberich, 2002). Shift workers, in particular, are believed to be at increased risk of injury, as they are chronically deprived of sleep, regular meal times, and other elements essential to the circadian clock (Gold *et al.*, 1992; Richardson *et al.*, 1989; Smith *et al.*, 1994).

Studies have documented that adolescents do not obtain adequate sleep due to the time constraints of school, activities and work (Carskadon, 2002; Dornbusch, 2002; Graham *et al.*, 2000). As described earlier, there appeared to be an increased risk of injury among adolescents employed in rural Minnesota who slept less than nine hours per night, compared with those who slept nine hours or more per night. During the summer months, risk was increased among working teens who slept less on weekend nights and, during the school months, risk was increased among young workers who slept less on school nights.

Among teens working during the summer, an increased risk of occupational injury was suggestive for any decrease in sleep quantity below nine hours of sleep per night, on average. The occupations of greatest concern were construction and farming. When specific sleep patterns were assessed, insufficient sleep at some time during the week

appeared to increase risk, even if optimal sleep was obtained on other nights. Individuals employed in seasonal activities, such as lifeguards and dockhands, who always reported insufficient or sub-optimal sleep, were at the greatest risk of work-related injury compared with adolescents employed in the same profession who slept nine hours or more every night.

Agricultural operations often share close proximity with rural households, and children and adolescents are exposed to many associated hazards, even if they are not employed by the operation (Gerberich *et al.*, 1993; 2003; 2004, Hard *et al.*, 1999). The increased risk seen among teens employed on ranches or farms, whether residents or not, underscores the importance of intervention in the rural population as a whole.

The findings from this study further enhance the knowledge base relevant to the overall importance of sleep for adolescents, especially adolescents involved in certain occupations. Of concern may be occupations that are often viewed as chores, as adolescents may not have received training to safely perform the tasks related to those positions. Sleep is a readily modifiable risk factor for injury among adolescents. The findings from this analysis are important in generating discussion about the overall importance of sleep for adolescents. While health effects from reduced sleep have been well documented recently, the role of sleepiness in the safety of teens must be considered also. Risk factors identified in this study may serve as a basis for further research and consideration of relevant intervention efforts.

Study Strengths and Limitations

Several strengths are important to this study. First, the size of the cohort was critical to this analysis. In total, 15,002 individuals completed almost 23,000

questionnaires during the two summers. The amount of information collected, which included demographics, work experience, and personal behaviors, as well as many other characteristics, allowed for an in-depth analysis.

This analysis was unique in that it did not include small sub-sets of a rural community, such as individuals injured severely enough to require hospitalization, or members of households associated with an agricultural operation, as has been done in many prior studies. Rather, these data enumerated young adults who lived in rural Minnesota communities and attended public high schools. Thus, the increased injury risk among farm residents, compared with that of their peers, who had similar schedules and lifestyles, is noteworthy.

Limitations of this study should be considered when interpreting results. One concern is the lack of clear association between sleep per night and an injury event, because data were collected to address average sleep per night rather than exact sleep prior to an injury event. Work hours for this study were reported on a daily basis, but then were averaged over time. This allowed for wide variation, as an individual could work many hours per day for a few days a week, or work several days a week for only a few hours, and still have the same average work hours. Research shows that adolescents working more than 20 hours per week are at increased risk for injury (Carskadon, 1990), emotional distress, and cigarette and alcohol use (Resnick *et al.*, 1997); however, in the current study, the schedule by which adolescents worked those hours was not fully examined.

Although schools were randomly selected to participate, some selection bias may have been possible in view of the willingness of the school administration to actively

engage in such extracurricular activities. Typically, it was more likely that a school would participate if there had been a recent publicized account of work injury or if the principal or faculty had personal concerns about the work history or injury events among adolescents in the community. Therefore, heightened awareness of the issues of work and injury could have potentially contributed to bias.

Other potential biases include the lack of information on caffeine intake and the role this may have played on sleep quantity among employed adolescents. However a sensitivity analysis showed that this unmeasured confounder would have been unlikely to nullify the study results; it was determined that the magnitude and direction of the effects of sleep on adolescents' risk of work-related injury were largely unchanged when accounting for caffeine use as a potential source of study error.

Study Validity

Observational studies are susceptible to error due to dependence on assumptions in the design, methods, and analysis phases; the non-random assignment of study subjects to exposure categories, particularly for the reference population, is a primary concern. The study described here utilized data from the Childhood Agricultural Trauma Evaluation System (CATES) (Williams *et al.*, 2006). Through careful study design and implementation, every attempt was made to minimize issues of bias. Potential biases were additionally assessed through sensitivity analyses evaluating the impact of potential measurement error and confounding biases on the study results (Greenland and Kleinbaum, 1983).

Information Bias

Measurement error has been described as a serious threat to the validity of epidemiologic studies, as it can produce a large amount of bias (Maldonado, 1993; Greenland, 1990; Copeland *et al.*, 1977; Dosemeci *et al.*, 1990; Gilbert, 1991; Flegal *et al.*, 1991; Wacholder *et al.*, 1991). The potential for measurement error was an important consideration in this study, as it is anticipated that there was some level of measurement error in the reporting of both injury events and the sleep exposures pertinent to these events.

It is anticipated that there is a potential for measurement error in the reporting of both injury events and exposures that were examined as potential risk factors for these events, due to the self-reported nature of the information, the time-dependent memory decay, and the nature of the participants.

Recall bias from the self-reporting of exposures on the Fall 2001 and Fall 2002 questionnaires was minimized by using a time period of three months as the exposure period of interest. The Spring questionnaire cycles, which covered the entire school year, may have had an increased risk of bias due to the longer time covered by each cycle. This concern was addressed through comprehensive training of school personnel who administered the questionnaires; however, the potential for gaps in recall exists.

Selection Bias

The cohort study design is based on a complete enumeration of a population with some common feature that is, then, followed over time. The sampling protocol for the CATES study enumerated all students attending public high schools (grades 9-12) with class size greater than 25 students in all 67 counties classified as rural by the USDA.

However, it is possible for selection bias to occur, either at the level of the school, the classroom, or the student. Some schools ultimately chose not to participate for several reasons; these included concerns about “over-surveying,” while others were uneasy about the time commitment by faculty and staff. At the classroom level, several teachers chose not to allow their students to participate in the survey administration due to what they perceived to be the sensitive nature of many questions and concerns about government involvement. Finally, students were allowed to refuse to participate at any time. As with bias due to measurement error, it is not possible to fully correct effect estimates for selection bias.

Sensitivity Analyses

Confounding

Sensitivity analyses were conducted to assess the magnitude and direction of potential bias from the omission of an unmeasured confounder that increased the odds of adolescent injury by factors of 0.5 up to 5. Using methods described by Rothman and Greenland (1998), analyses were conducted to generate a range of estimates for the odds of injury, adjusted for the prevalence of the unmeasured confounder of the use of caffeine and other stimulants, among well-rested adolescents, versus sleep-deprived adolescents. Caffeine is considered to be the most widely used psychoactive substance. It is believed to be used at least weekly by as much as 98% of the population under 18 years of age, mostly in the form of carbonated beverages (Pollak and Bright, 2003); adolescents reporting high caffeine intake have been almost two times more likely to report difficulty sleeping (Roehrs and Roth, 2008).

Attrition

The number of those adolescents responding to questionnaires generally declined throughout the two-year study. Students who supplied information during the later time periods were compared with students who completed the initial questionnaire, to assess similarities and differences in responses. Overall, as shown in **Table 1**, comparisons showed little change in population responses, despite the decrease in the number of students completing questionnaires.

Conclusions

Despite potential limitations due to error factors, this study contributes important information to the fields of adolescent health and safety, sleep research, and injury epidemiology. Important traits were identified as contributing to adolescent injury. Findings from this study suggest a need for a more focused understanding of adolescent injury prevention and the role of adequate sleep, both during the summer months, and the school year. In particular, the increased risk of injury among girls who slept less than the optimal nine hours of sleep per night compared with girls who slept nine or more hours per night suggests a need to more closely assess the role of gender in sleep and injury. Further, the evidence that sleep deprivation increased the overall risk of injury, among farm residents who were working on agricultural operations, is also an important consideration. Further research should consider the role of sleep as a risk factor for adolescent injury and, relevant intervention efforts, both during the school year and during summer months should be assessed.

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Table 1: Odds ratios and 95% confidence intervals for reduced sleep as a risk factor for injury among Minnesota adolescents, Year 1 data compared with all data

Characteristics	Week Night Sleep	Weekend Night Sleep	All Time Periods		Year 1 Only		Week Night Sleep	Weekend Night Sleep	All Time Periods		Year 1 Only	
			OR All Data	95% CI All data	OR Year 1 data	95% CI Year 1 data			OR All data	95% CI All data	OR Year 1 data	95% CI Year 1 data
Gender¹												
Boys	≥ 6 hrs	< 6 hrs	1.19	0.99,1.44	1.23	0.99,1.53	≥ 8 hrs	< 8 hrs	1.01	0.85,1.20	1.13	0.93,1.37
	< 6 hrs	≥ 6 hrs	1.26	0.94,1.70	1.26	0.88,1.82	< 8 hrs	≥ 8 hrs	1.20	1.01,1.41	1.13	0.93,1.38
	< 6 hrs	< 6 hrs	1.07	0.82,1.39	1.11	0.80,1.54	< 8 hrs	< 8 hrs	1.05	0.89,1.24	1.12	0.93,1.35
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Girls	≥ 6 hrs	< 6 hrs	1.57	1.27,1.94	1.68	1.32,2.14	≥ 8 hrs	< 8 hrs	1.39	1.16,1.67	1.30	1.05,1.61
	< 6 hrs	≥ 6 hrs	2.48	1.84,3.34	2.37	1.65,3.41	< 8 hrs	≥ 8 hrs	1.33	1.12,1.59	1.36	1.12,1.67
	< 6 hrs	< 6 hrs	1.97	1.47,2.64	1.79	1.23,2.61	< 8 hrs	< 8 hrs	1.51	1.27,1.81	1.67	1.36,2.04
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Lived on a Farm²												
Yes	≥ 6 hrs	< 6 hrs	2.03	1.40,2.96	1.91	1.23,2.96	≥ 8 hrs	< 8 hrs	1.51	1.07,2.12	1.65	1.12,2.43
	< 6 hrs	≥ 6 hrs	3.54	2.10,5.98	3.22	1.72,6.02	< 8 hrs	≥ 8 hrs	1.31	0.90,1.91	1.45	0.94,2.25
	< 6 hrs	< 6 hrs	2.60	1.66,4.08	2.47	1.37,4.45	< 8 hrs	< 8 hrs	2.04	1.48,2.82	2.11	1.45,3.06
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
No	≥ 6 hrs	< 6 hrs	1.27	1.09,1.48	1.36	1.14,1.62	≥ 8 hrs	< 8 hrs	1.13	0.99,1.29	1.16	0.99,1.35

	< 6 hrs	≥ 6 hrs	1.52	1.20,1.92	1.51	1.13,2.01	< 8 hrs	≥ 8 hrs	1.24	1.09,1.40	1.20	1.04,1.40
	< 6 hrs	< 6 hrs	1.20	0.96,1.50	1.24	0.93,1.63	< 8 hrs	< 8 hrs	1.11	0.97,1.27	1.22	1.05,1.41
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Grade in School³												
Freshman	≥ 6 hrs	< 6 hrs	1.81	1.40,2.33	1.81	1.40,2.33	≥ 8 hrs	< 8 hrs	1.45	1.16,1.81	1.45	1.16,1.81
	< 6 hrs	≥ 6 hrs	2.29	1.47,3.56	2.29	1.47,3.56	< 8 hrs	≥ 8 hrs	1.20	0.95,1.52	1.20	0.95,1.52
	< 6 hrs	< 6 hrs	1.05	0.65,1.70	1.05	0.65,1.70	< 8 hrs	< 8 hrs	1.54	1.23,1.93	1.54	1.23,1.93
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Sophomore	≥ 6 hrs	< 6 hrs	1.29	1.01,1.66	1.10	0.81,1.50	≥ 8 hrs	< 8 hrs	1.19	0.96,1.46	1.11	0.86,1.43
	< 6 hrs	≥ 6 hrs	1.66	1.14,2.40	1.52	0.95,2.42	< 8 hrs	≥ 8 hrs	1.42	1.17,1.73	1.27	1.00,1.62
	< 6 hrs	< 6 hrs	1.42	1.02,1.98	1.13	0.74,1.75	< 8 hrs	< 8 hrs	1.22	0.99,1.49	1.16	0.90,1.49
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Junior	≥ 6 hrs	< 6 hrs	1.49	1.14,1.95	1.51	1.11,2.05	≥ 8 hrs	< 8 hrs	1.28	1.00,1.63	1.21	0.91,1.60
	< 6 hrs	≥ 6 hrs	1.68	1.11,2.52	1.44	0.90,2.32	< 8 hrs	≥ 8 hrs	1.47	1.17,1.85	1.38	1.06,1.80
	< 6 hrs	< 6 hrs	1.75	1.23,2.47	1.75	1.15,2.66	< 8 hrs	< 8 hrs	1.48	1.18,1.85	1.49	1.15,1.93
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Senior	≥ 6 hrs	< 6 hrs	1.6	1.01,2.53	4.02	0.02,10.8	≥ 8 hrs	< 8 hrs	1.02	0.64,1.62	1.15	0.28,4.73
	< 6 hrs	≥ 6 hrs	2.78	1.57,4.92	5.91	1.28,27.2	< 8 hrs	≥ 8 hrs	1.25	0.82,1.89	1.19	0.29,4.82
	< 6 hrs	< 6 hrs	1.99	1.15,3.45	5.08	1.22,21.1	< 8 hrs	< 8 hrs	1.56	1.04,2.33	2.61	0.83,8.24
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Current Smoker⁴												

Yes	≥ 6 hrs	< 6 hrs	1.36	1.00,1.84	1.27	0.88,1.84	≥ 8 hrs	< 8 hrs	1.05	0.76,1.44	0.94	0.65,1.37
	< 6 hrs	≥ 6 hrs	1.62	1.03,2.53	1.54	0.91,2.62	< 8 hrs	≥ 8 hrs	1.19	0.87,1.63	1.13	0.79,1.64
	< 6 hrs	< 6 hrs	1.28	0.87,1.88	**	**	< 8 hrs	< 8 hrs	1.31	0.98,1.75	1.29	0.92,1.81
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
No	≥ 6 hrs	< 6 hrs	1.36	1.15,1.60	1.36	1.12,1.65	≥ 8 hrs	< 8 hrs	1.27	1.10,1.46	1.26	1.08,1.47
	< 6 hrs	≥ 6 hrs	1.78	1.38,2.30	1.64	1.20,2.24	< 8 hrs	≥ 8 hrs	1.36	1.19,1.55	1.25	1.07,1.46
	< 6 hrs	< 6 hrs	1.38	1.07,1.77	1.37	1.01,1.86	< 8 hrs	< 8 hrs	1.32	1.15,1.51	1.36	1.16,1.59
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Alcohol use > 5 days/mnth⁵												
Yes	≥ 6 hrs	< 6 hrs	1.29	0.98,1.70	1.22	0.88,1.69	≥ 8 hrs	< 8 hrs	1.16	0.88,1.53	**	**
	< 6 hrs	≥ 6 hrs	2.5	1.63,3.39	2.28	1.47,3.54	< 8 hrs	≥ 8 hrs	1.39	1.07,1.81	1.21	0.86,1.68
	< 6 hrs	< 6 hrs	1.40	0.99,1.97	1.52	0.99,2.34	< 8 hrs	< 8 hrs	1.27	0.98,1.65	1.29	0.95,1.75
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
No	≥ 6 hrs	< 6 hrs	1.45	1.22,1.72	1.48	1.22,1.80	≥ 8 hrs	< 8 hrs	1.26	1.10,1.46	1.22	1.03,1.43
	< 6 hrs	≥ 6 hrs	1.57	1.19,2.08	1.45	1.04,2.02	< 8 hrs	≥ 8 hrs	1.35	1.18,1.55	1.28	1.10,1.50
	< 6 hrs	< 6 hrs	1.41	1.08,1.82	1.16	0.83,1.62	< 8 hrs	< 8 hrs	1.36	1.18,1.56	1.37	1.17,1.61
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
>3 hours/day in Sports⁶												
Yes	≥ 6 hrs	< 6 hrs	1.54	1.26,1.89	1.51	1.20,1.90	≥ 8 hrs	< 8 hrs	1.32	1.11,1.58	1.30	1.07,1.58
	< 6 hrs	≥ 6 hrs	2.00	1.48,2.69	2.05	1.44,2.92	< 8 hrs	≥ 8 hrs	1.33	1.09,1.62	1.27	1.01,1.60
	< 6 hrs	< 6 hrs	1.54	1.17,2.02	1.56	1.12,2.19	< 8 hrs	< 8 hrs	1.40	1.18,1.67	1.49	1.22,1.81

	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent
No	≥ 6 hrs	< 6 hrs	1.49	1.20,1.85	1.52	1.17,1.97	≥ 8 hrs	< 8 hrs	1.23	1.01,1.50	1.22	0.97,1.54
	< 6 hrs	≥ 6 hrs	1.62	1.17,2.24	1.32	0.87,2.01	< 8 hrs	≥ 8 hrs	1.26	1.04,1.54	1.11	0.88,1.41
	< 6 hrs	< 6 hrs	1.40	1.05,1.86	1.14	0.78,1.65	< 8 hrs	< 8 hrs	1.39	1.16,1.66	1.34	1.07,1.67
	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent
>8 hours/day at work⁷												
Yes	≥ 6 hrs	< 6 hrs	1.44	1.15,1.81	1.33	1.02,1.73	≥ 8 hrs	< 8 hrs	1.18	0.98,1.44	1.15	0.92,1.43
	< 6 hrs	≥ 6 hrs	2.01	1.46,2.76	1.59	1.08,2.33	< 8 hrs	≥ 8 hrs	1.26	1.02,1.56	1.10	0.86,1.41
	< 6 hrs	< 6 hrs	1.64	1.22,2.20	1.49	1.05,2.10	< 8 hrs	< 8 hrs	1.44	1.19,1.74	1.42	1.14,1.76
	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent
No	≥ 6 hrs	< 6 hrs	1.16	0.93,1.45	1.29	1.00,1.68	≥ 8 hrs	< 8 hrs	1.17	0.97,1.41	1.15	0.93,1.42
	< 6 hrs	≥ 6 hrs	1.24	0.90,1.71	1.28	0.87,1.88	< 8 hrs	≥ 8 hrs	1.13	0.94,1.36	1.06	0.85,1.33
	< 6 hrs	< 6 hrs	0.94	0.67,1.31	0.87	0.56,1.36	< 8 hrs	< 8 hrs	1.06	0.88,1.27	1.16	0.93,1.44
	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent
Went to Sleep after Midnight⁸												
Yes	≥ 6 hrs	< 6 hrs	1.28	0.98,1.67	1.17	0.85,1.62	≥ 8 hrs	< 8 hrs	1.24	0.97,1.60	1.09	0.76,1.56
	< 6 hrs	≥ 6 hrs	1.65	1.16,2.35	1.43	0.91,2.25	< 8 hrs	≥ 8 hrs	1.29	0.97,1.72	1.05	0.73,1.51
	< 6 hrs	< 6 hrs	1.12	0.80,1.56	1.17	0.75,1.81	< 8 hrs	< 8 hrs	1.04	0.83,1.31	1.09	0.83,1.44
	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent	≥ 9 hrs	≥ 9 hrs	1.0	Referent	1.0	Referent
No	≥ 6 hrs	< 6 hrs	1.56	1.26,1.93	1.62	1.27,2.06	≥ 8 hrs	< 8 hrs	1.29	1.08,1.54	1.28	1.05,1.56

	< 6 hrs	≥ 6 hrs	1.61	1.10,2.36	2.01	1.33,3.04	< 8 hrs	≥ 8 hrs	1.27	1.06,1.52	1.17	0.95,1.44
	< 6 hrs	< 6 hrs	1.48	1.01,2.18	1.42	0.89,2.27	< 8 hrs	< 8 hrs	1.48	1.23,1.77	1.53	1.24,1.88
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>
Multivariate Model⁹												
	≥ 6 hrs	< 6 hrs	1.20	1.01,1.42	1.30	1.06,1.59	≥ 8 hrs	< 8 hrs	1.10	0.96,1.28	1.12	0.95,1.32
	< 6 hrs	≥ 6 hrs	1.59	1.23,2.04	1.59	1.17,2.16	< 8 hrs	≥ 8 hrs	1.24	1.06,1.45	1.11	0.92,1.33
	< 6 hrs	< 6 hrs	1.13	0.87,1.48	1.18	0.86,1.63	< 8 hrs	< 8 hrs	1.25	1.08,1.45	1.32	1.11,1.56
	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>	≥ 9 hrs	≥ 9 hrs	1.0	<i>Referent</i>	1.0	<i>Referent</i>

** - data too sparse to fit model

1-models included grade in school, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

2-models included gender, grade in school, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

3-models included gender, lived on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

4-models included gender, grade in school, live on farm, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep.

5-model included gender, grade in school, live on farm, smoking status, hours in organized/recreational sports, hours at work, and time to sleep.

6-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours at work, and time to sleep.

7-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and time to sleep.

8-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, and hours at work.

9-models included gender, grade in school, live on farm, smoking status, alcohol consumption, hours in organized/recreational sports, hours at work, and time to sleep

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APPENDICES

CATES QUESTIONNAIRES

FALL

SPRING

**YOUTH AT WORK:
FALL INJURY SURVEY**

Please fill in today's date:

MONTH	DAY	YEAR
① January ⑦ July	① ①	○ 2001
② February ⑧ August	① ①	○ 2002
③ March ⑨ September	② ②	○ 2003
④ April ⑩ October	③ ③	
⑤ May ①① November	④	
⑥ June ①② December	⑤	
	⑥	
	⑦	
	⑧	
	⑨	

DEMOGRAPHICS

1. What is your date of birth?

MONTH	DAY	YEAR
① January ⑦ July	① ①	○ 1983
② February ⑧ August	① ①	○ 1984
③ March ⑨ September	② ②	○ 1985
④ April ⑩ October	③ ③	○ 1986
⑤ May ①① November	④	○ 1987
⑥ June ①② December	⑤	○ 1988
	⑥	○ 1989
	⑦	
	⑧	
	⑨	

2. What is your gender?

Male Female

3. What is your grade?

9th 10th 11th 12th

4. Are you of Hispanic or Latino origin or descent?

Hispanic or Latino
 Not Hispanic or Latino

5. Which of these groups BEST describes you? (Mark one or more):

African American or Black
 American Indian or Alaskan Native
 Asian
 Native Hawaiian/Pacific Islander
 White or Caucasian
 Other (please print) _____

6. Do you live on a farm or a ranch that is actively involved in agricultural production? *A Farm is defined as any place that would produce or sell \$1,000 or more of agricultural products.*

Yes
 No

A. If YES, what type of farming or ranching is done? (Please choose major activities that apply):

Beef Cattle Dairy Hogs
 Small grains Row crops
 Turkeys, poultry Other, please specify _____

SCHOOL ACTIVITIES

Please fill in the questions below to describe an average DAY during the months of JUNE, JULY, and AUGUST.

School Time: This category includes all hours spent in classroom activities (do not include extracurricular activities) including time spent outside of regular school hours doing homework.

7. Did you attend summer school during the months of June, July and August? Do not include any days in June spent in the regular school calendar.

Yes



No (SKIP TO page 2, question 11)

8. What was the usual time you arrived on school property?

Time:	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11 12
Hours	<input type="checkbox"/> Morning (a.m.) <input type="checkbox"/> Evening (p.m.)
Minutes	00 15 30 45

9. What was the usual time you left school property?

Time:	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11 12
Hours	<input type="checkbox"/> Morning (a.m.) <input type="checkbox"/> Evening (p.m.)
Minutes	00 15 30 45

10. Approximately how many hours of homework did you typically have each day during June, July and August?

none 1 hour
 2 hours 3 hours
 4 hours 5 hours
 6 hours 7 hours
 8 hours

SLEEP AND OTHER ACTIVITIES

Please answer questions 11-18 to describe an average DAY during the months of **JUNE, JULY, and AUGUST**. Please read the following definitions to help you answer these questions:

Sleep: The time you spent sleeping at night.
Other Activities: This refers to all non-work or school activities that you may have been involved in during June, July and August such as:

- Time spent driving or being driven to school, work, etc.
- Time spent in extracurricular activities such as organized sports, supervised club activities.
- Time spent in recreational activities such as horseback riding, ATV riding, non-supervised sporting activities.

11. What time did you usually get up during WEEKDAYS (Monday through Friday) in June, July and August?

Hour	① ② ③ ④ ⑤ ⑥ ⑦
	⑧ ⑨ ⑩ 11 12
	<input type="checkbox"/> Morning <input type="checkbox"/> Evening
Minutes	00 15 30 45

12. What time did you usually go to sleep during WEEKNIGHTS (Sunday through Thursday) in June, July and August?

Hour	① ② ③ ④ ⑤ ⑥ ⑦
	⑧ ⑨ ⑩ 11 12
	<input type="checkbox"/> Morning <input type="checkbox"/> Evening
Minutes	00 15 30 45

13. What is the average amount of sleep you got on WEEKNIGHTS (Sunday through Thursday) in June, July and August?

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧
	⑨ ⑩ 11 12 13 14
Minutes	00 15 30 45

14. What is the average amount of sleep you got on WEEKEND NIGHTS (Friday and Saturday) during June, July and August?

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

15. Approximately how much time did you spend driving or being driven to and from school or work on a typical WEEKDAY (Monday through Friday) during June, July and August?

No time spent in transportation

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

16. Approximately how much time did you spend driving or being driven to and from school or work on a typical WEEKEND (Saturday and Sunday) during June, July and August?

No time spent in transportation

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

17. Approximately how much time did you spend in organized sports, and/or supervised club activities in a TYPICAL DAY in June, July and August?

No time spent in organized sports, or supervised club activities

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

18. Approximately how much time did you spend in recreational sports and/or unsupervised activities in a TYPICAL DAY in June, July and August?

No time spent in recreational sports or unsupervised activities

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

WORK ACTIVITIES

Work Time: Did you work during the months of **June, July or August?** Work includes:

- Ⓡ Paid or unpaid employment either at or away from your home.
- Ⓡ Chores or work done for your family, such as lawn care, babysitting, dishes.
- Ⓡ Chores or work done outside of your home.
- Ⓡ Seasonal activities such as working harvest or lifeguarding.

19. Based on the definition above, did you work during the months of June, July and August?

- YES
 NO (SKIP TO page 7, question 27)

Job descriptions/codes

Personal services 01. lawn care 02. babysitting 03. maid/housekeeper 04. clean-up/janitorial worker 05. day care/child care worker 06. delivery person 07. car wash worker Restaurant/fast food 08. car hop or fast food server 09. cook-fast food 10. waitress/waiter 11. buser 12. dishwasher 13. hostess/host Construction/manufacturing/food processing 24. laborer 25. line worker	Retail 14. cashier 15. stock clerk 16. sales clerk 17. station attendant 18. grocery bagger Professional/medical 19. veterinarian's helper 20. teacher or teacher's aide 21. hospital orderly/ nursing home assistant/personal care assistant 22. receptionist/office staff 23. computer operator/programmer	Entertainment/recreation 26. amusement park attendant 27. lifeguard 28. recreation leader/camp counselor/sports instructor 29. dockhand 30. special events/activities (e.g. State Fair booth employee) Agricultural activities: 31. Work done on a farm under the supervision/ employment of a farmer 32. Work done on a farm as a service to the farmer, but under the supervision of an agri-business provider
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Please include information on all your work and chores in the table below. We have provided space for FOUR types of work or chores; if you need more space, please ask for additional paper.

	JOB 1	JOB 2	JOB 3	JOB 4
20. What type of work or chores did you do during June, July and August? (enter green 2-digit code from list on page 4)	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
21. How many hours did you work on a typical WEEKDAY OR WEEKNIGHT in June, July and August?	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16
22. How many hours did you work on a typical WEEKEND DAY OR NIGHT in June, July and August?	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16
23. During how many weeks of June, July or August did you work at this job or do these chores?	June ①②③④ July ①②③④ Aug. ①②③④	June①②③④ July ①②③④ Aug.①②③④	June①②③④ July ①②③④ Aug.①②③④	June①②③④ July ①②③④ Aug.①②③④

	JOB 1	JOB 2	JOB 3	JOB 4
24. What time did you typically START this job or these chores?	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②
25. What time did you typically END this job or these chores?	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ①① ② ①⑤ ③ ③① ④ ④⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②
26. Did you do any of these tasks in your job or chores? a. tractor/combine driver b. truck driver for transporting products/animals c. repair/maintaining machinery d. baling/stacking hay e. hand harvest of fruits, vegetables f. hoe, pick rocks, cut weeds g. general livestock chores (feeding, watering) h. milking cows i. building fences j. cleaning livestock barns/pens k. moving animals l. breeding animals m. pesticide application/tending spray trucks n. detasseling o. custom/crew hand harvesting p. custom/crew machine harvesting (custom combining, silage making, sugar beet lifting) q. poultry catching r. building cleaning s. manure pumping t. landscaping	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes r. <input type="checkbox"/> Yes s. <input type="checkbox"/> Yes t. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes r. <input type="checkbox"/> Yes s. <input type="checkbox"/> Yes t. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes r. <input type="checkbox"/> Yes s. <input type="checkbox"/> Yes t. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes r. <input type="checkbox"/> Yes s. <input type="checkbox"/> Yes t. <input type="checkbox"/> Yes
27. During your work or chores, did you participate in any of the following activities? a. operating power machines, (e.g. tractors, combines) except motor vehicles b. operating power hand tools c. operating non-power hand tools/utensils/knives d. lifting/bending/twisting e. using chemicals f. driving a car or truck g. working with animals h. climbing/working from heights i. working around hot surfaces	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes

INJURY/ACCIDENT EXPERIENCE

Please provide information on injuries or accidents that you have experienced. There are many different kinds of injuries: burns, broken bones, bruises, cuts, strains, sprains, or poisonings. This question asks about any injury or accident that:

- Restricted your normal activities for at least 4 hours;
AND/OR
- Resulted in a loss of consciousness, loss of awareness, or amnesia for any length of time;
AND/OR
- Caused you to seek professional health care, including care by doctors, nurses, chiropractors, dentists, or other healthcare professionals.

28. According to this definition, were you injured during June, July or August?

- Yes
 No (**SKIP TO page 9, question 36**)

Please fill in the following table describing any injuries that you experienced during **JUNE, JULY and AUGUST**. We have provided you with space to describe four different injury events that may have occurred during June, July, and August. If you need additional space, please ask for more paper.

	INJURY1	INJURY 2	INJURY3	INJURY 4
29. Where did your injury or accident occur?	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity
30. In what month did your injury or accident occur?	① June ② July ③ August			
31. What body part(s) were injured? (please mark all that apply).	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin
32. What type of injury did you have? (please mark all that apply).	① Bruise/abrasion ② Cut ③ Burn ④ Concussion/Loss of Consciousness ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/Dislocation ⑧ Chemical	① Bruise/abrasion ② Cut ③ Burn ④ Concussion/Loss of Consciousness ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/Dislocation ⑧ Chemical	① Bruise/abrasion ② Cut ③ Burn ④ Concussion/Loss of Consciousness ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/Dislocation ⑧ Chemical	① Bruise/abrasion ② Cut ③ Burn ④ Concussion/Loss of Consciousness ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/Dislocation ⑧ Chemical

	INJURY1	INJURY 2	INJURY3	INJURY 4
	exposure ⑨ Other	exposure ⑨ Other	exposure ⑨ Other	exposure ⑨ Other
33. Were you treated by any of the following as a result of this event? (please mark all that apply).	① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment	① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment	① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment	① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment
34. As a result of this injury or accident, how long were your normal activities restricted? Normal activities are things that you would expect to do on a regular basis.	① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted	① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted	① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted	① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted
35. As a result of this injury or accident, have you had any permanent disabling problems?	① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪⑪ Chronic pain	① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪⑪ Chronic pain	① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪⑪ Chronic pain	① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪⑪ Chronic pain
36. How much school did you miss due to this	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1

	INJURY1	INJURY 2	INJURY3	INJURY 4
injury or accident?	month Ⓒ more than 1 month Ⓔ Unsure			
37. How much work did you miss due to this injury or accident?	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure
38. How much work did your parent or guardian miss due to this injury or accident?	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure	Ⓐ None Ⓑ 1 day or less Ⓒ 1 day to 1 week Ⓓ 8 days to 2 weeks Ⓔ 15 days to 1 month Ⓕ more than 1 month Ⓖ Unsure

PERSONAL BEHAVIORS

39. During the past 12 months, how would you describe your grades in school?

- Mostly A's Mostly D's
 Mostly B's Mostly F's
 Mostly C's None of these
 Not sure

40. During June, July and August did you drive a motor vehicle (car, truck)?

- Yes
 No

41. How often do you wear a seat belt when riding in or driving a car?

- Always Rarely
 Sometimes Never

42. Have you ever used chewing tobacco, snuff, or dip?

- Yes
 No

43. Do you CURRENTLY smoke cigarettes?

- Yes
 No

A. If YES, during the past 30 days, on the days you smoked, how many cigarettes did you smoke per day?

- less than one cigarette per day
 1 cigarette per day
 2 to 5 cigarettes per day
 6 to 10 cigarettes per day
 11 to 20 cigarettes per day
 More than 20 cigarettes/day

B. During June, July and August did you smoke cigarettes?

- Yes
 No

44. At home, do people smoke cigarettes around you?

- Often Rarely
 Sometimes Never

45. Do your friends smoke cigarettes around you?

- Often Rarely
 Sometimes Never

46. If you work, do people smoke at your place of work?

- Often Rarely
 Sometimes Never

47. During June, July and August, on how many days did you have at least one drink of alcohol? *A drink is 1 can or bottle of beer, 1 glass of wine or wine cooler, 1 cocktail, or 1 shot.*

- 0 days
 1 or 2 days
 3 to 5 days
 6 to 9 days
 10 to 19 days
 20 to 29 days
 All 30 days

48. During June, July and August, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?

- 0 days
 1 or 2 days
 3 to 5 days
 6 to 9 days
 10 to 19 days
 20 or more days

49. What is your height? Please fill in the corresponding ovals below.

HEIGHT	
Feet	In.
③	①
④	①
⑤	②
⑥	③
⑦	④
	⑤
	⑥
	⑦
	⑧
	⑨
	⑩
	①①

50. What is your weight? Please fill in the corresponding ovals below.

WEIGHT IN POUNDS		
①	①	①
①	①	①
②	②	②
③	③	③
④	④	④
⑤	⑤	⑤
⑥	⑥	⑥
⑦	⑦	⑦
⑧	⑧	⑧
⑨	⑨	⑨

ASTHMA INFORMATION

51. Have you had wheezing or whistling in your chest in the past 12 months?

- Yes
 No

52. Have you had wheezing or whistling in your chest in the past 12 months when you exercise?

- Yes
 No

53. Has a doctor ever told you that you have asthma?

- Yes

No ☞ **THANK YOU FOR COMPLETING THIS SURVEY. PLEASE TURN IN YOUR FORM.**

A. If YES, do you still have asthma?

- Yes
 No

B. If YES, is your asthma work-related?

- Yes
 No

54. Do you have a regular doctor or clinic where you go for asthma care?

- Yes
 No

55. Does your asthma bother you (check one)?

- Less than once a week
 About 2-3 times per week
 Almost every day

56. Do you have an Asthma Action Plan?

An Asthma Action Plan is a form with instructions about how to care for your asthma.

- Yes
 No

57. Do you have asthma medications that you take or inhale every day whether or not you have symptoms?

- Yes
 No

58. Do you have asthma medications that you take or inhale only when you have symptoms?

- Yes
 No

59. Do you have asthma medications that you take or inhale before you exercise?

- Yes
 No

60. During the past 30 days, how much time did you miss from the following activities due to asthma?

A. SCHOOL:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

B. WORK:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

C. ORGANIZED SPORTS:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

D. RECREATIONAL ACTIVITIES:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

THANK YOU FOR COMPLETING THIS SURVEY. PLEASE TURN IN YOUR FORM.

**YOUTH AT WORK:
SPRING INJURY SURVEY**

Please fill in today's date:

MONTH	DAY	YEAR
① January ⑦ July	① ①	○ 2001
② February ⑧ August	② ②	○ 2002
③ March ⑨ September	③ ③	○ 2003
④ April ⑩ October	④	
⑤ May ① ① November	⑤	
⑥ June ① ② December	⑥	
	⑦	
	⑧	
	⑨	

DEMOGRAPHICS

1. What is your date of birth?

MONTH	DAY	YEAR
① January ⑦ July	① ①	○ 1983
② February ⑧ August	② ②	○ 1984
③ March ⑨ September	③ ③	○ 1985
④ April ⑩ October	④	○ 1986
⑤ May ① ① November	⑤	○ 1987
⑥ June ① ② December	⑥	○ 1988
	⑦	○ 1988
	⑧	○ 1989
	⑨	

2. What is your gender?

Male Female

3. What is your grade?

9th 10th 11th 12th

4. Are you of Hispanic or Latino origin or descent?

Hispanic or Latino
 Not Hispanic or Latino

5. Which of these groups BEST describes you? (Mark one or more):

African American or Black
 American Indian or Alaskan Native
 Asian
 Native Hawaiian/Pacific Islander
 White or Caucasian
 Other (please print) _____

6. Do you live on a farm or a ranch that is actively involved in agricultural production? *A Farm is defined as any place that would produce or sell \$1,000 or more of agricultural products.*

Yes
 No

A. If YES, what type of farming or ranching is done? (Please choose major activities that apply):

Beef Cattle Dairy Hogs
 Small grains Row crops

Turkeys, poultry Other, please specify _____

SCHOOL ACTIVITIES

Please fill in the questions below to describe an average DAY during the months of **SEPTEMBER THROUGH MAY**.

School Time: This category includes all hours spent in classroom activities (do not include extracurricular activities) including time spent outside of regular school hours doing homework.

7. Did you attend summer school during the months of September through May?

Yes
 No (SKIP TO page 2, question 11)

8. What was the usual time you arrived on school property?

Time:	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11 12
Hours	<input type="checkbox"/> Morning (a.m.) <input type="checkbox"/> Evening (p.m.)
Minutes	01 15 30 45

9. What was the usual time you left school property?

Time:	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11 12
Hours	<input type="checkbox"/> Morning (a.m.) <input type="checkbox"/> Evening (p.m.)
Minutes	01 15 30 45

10. Approximately how many hours of homework did you typically have each day during September through May?

none 1 hour
 2 hours 3 hours
 4 hours 5 hours
 6 hours 7 hours
 8 hours

SLEEP AND OTHER ACTIVITIES

Please answer questions 11-18 to describe an average DAY during the months of **SEPTEMBER THROUGH MAY**. Please read the following definitions to help you answer these questions:

Sleep: The time you spent sleeping at night.

Other Activities: This refers to all non-work or school activities that you may have been involved in during **September through May** such as:

- Time spent driving or being driven to school, work, etc.
- Time spent in extracurricular activities such as organized sports, supervised club activities.
- Time spent in recreational activities such as horseback riding, ATV riding, non-supervised sporting activities.

11. What time did you usually get up during WEEKDAYS (Monday through Friday) in September through May?

Hour	① ② ③ ④ ⑤ ⑥ ⑦
	⑧ ⑨ ⑩ 11 12
	<input type="checkbox"/> Morning <input type="checkbox"/> Evening
Minutes	01 15 30 45

12. What time did you usually go to sleep during WEEKNIGHTS (Sunday through Thursday) in September through May?

Hour	① ② ③ ④ ⑤ ⑥ ⑦
	⑧ ⑨ ⑩ 11 12
	<input type="checkbox"/> Morning <input type="checkbox"/> Evening
Minutes	01 15 30 45

13. What is the average amount of sleep you got on WEEKNIGHTS (Sunday through Thursday) in September through May?

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧
	⑨ ⑩ 11 12 13 14
Minutes	01 15 30 45

14. What is the average amount of sleep you got on WEEKEND NIGHTS (Friday and Saturday) during September through May?

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	00 15 30 45

15. Approximately how much time did you spend driving or being driven to and from school or work on a typical WEEKDAY (Monday through Friday) during September through May?

No time spent in transportation

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	01 15 30 45

16. Approximately how much time did you spend driving or being driven to and from school or work on a typical WEEKEND (Saturday and Sunday) during September through May?

No time spent in transportation

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	01 15 30 45

17. Approximately how much time did you spend in organized sports, and/or supervised club activities in a TYPICAL DAY in September through May?

No time spent in organized sports, or supervised club activities

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	01 15 30 45

18. Approximately how much time did you spend in recreational sports and/or unsupervised activities in a TYPICAL DAY in September through May?

No time spent in recreational sports or unsupervised activities

Hours	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
	11 12 13 14
Minutes	01 15 30 45

WORK ACTIVITIES

Work Time: Did you work during the months of **September through May**? Work includes:

- Paid or unpaid employment either at or away from your home.
- Chores or work done for your family, such as lawn care, babysitting, dishes.
- Chores or work done outside of your home.
- Seasonal activities such as working harvest or lifeguarding.

19. Based on the definition above, did you work during the months of September through May?

- YES
 NO (SKIP TO page 7, question 27)

Job descriptions/codes

Personal services 01. lawn care 02. babysitting 03. maid/housekeeper 04. clean-up/janitorial worker 05. day care/child care worker 06. delivery person 07. car wash worker Restaurant/fast food 08. car hop or fast food server 09. cook-fast food 10. waitress/waiter 11. buser 12. dishwasher 13. hostess/host Construction/manufacturing/ food processing 24. laborer 25. line worker	Retail 14. cashier 15. stock clerk 16. sales clerk 17. station attendant 18. grocery bagger Professional/medical 19. veterinarian's helper 20. teacher or teacher's aide 21. hospital orderly/ nursing home assistant/personal care assistant 22. receptionist/office staff 23. computer operator/programmer	Entertainment/recreation 26. amusement park attendant 27. lifeguard 28. recreation leader/camp counselor/sports instructor 29. dockhand 30. special events/activities (e.g. State Fair booth employee) Agricultural activities: 31. Work done on a farm under the supervision/ employment of a farmer 32. Work done on a farm as a service to the farmer, but under the supervision of an agri-business provider
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Please include information on all your work and chores in the table below. We have provided space for FOUR types of work or chores; if you need more space, please ask for additional paper.

	JOB 1	JOB 2	JOB 3	JOB 4
20. What type of work or chores did you do during September through May? (enter green 2-digit code from list on page 4)	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
21. How many hours did you work on a typical WEEKDAY OR WEEKNIGHT in September through May?	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16
22. How many hours did you work on a typical WEEKEND DAY OR NIGHT in September through May?	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ 10 11 12 13 14 15 16
23. During how many weeks of September through May did you work at this job or do these chores?	Sept. ① ② ③ ④ Oct.			

	JOB 1	JOB 2	JOB 3	JOB 4
	①②③④ Nov. ①②③④ Dec. ①②③④ Jan. ①②③④ Feb. ①②③④ Mar. ①②③④ Apr. ①②③④ May ①②③④	①②③④ Nov. ①②③④ Dec. ①②③④ Jan. ①②③④ Feb. ①②③④ Mar. ①②③④ Apr. ①②③④ May ①②③④	①②③④ Nov. ①②③④ Dec. ①②③④ Jan. ①②③④ Feb. ①②③④ Mar. ①②③④ Apr. ①②③④ May ①②③④	①②③④ Nov. ①②③④ Dec. ①②③④ Jan. ①②③④ Feb. ①②③④ Mar. ①②③④ Apr. ①②③④ May ①②③④
24. What time did you typically START this job or these chores?	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②
25. What time did you typically END this job or these chores?	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②	① ① ① ② ① ⑤ ③ ③ ① ④ ④ ⑤ ⑤ <input type="checkbox"/> a.m. ⑥ <input type="checkbox"/> p.m. ⑦ ⑧ ⑨ ⑩ ①① ①②
26. Did you do any of these tasks in your job or chores? a. tractor/combine driver b. truck driver for transporting products/animals c. repairing/maintaining machinery d. baling/stacking hay e. hand harvest of fruits, vegetables f. hoeing, picking rocks, cutting weeds g. general livestock chores (feeding, watering) h. milking cows i. building fences j. cleaning livestock barns/pens k. moving animals l. breeding animals m. pesticide application/tending spray trucks n. detasseling o. custom/crew hand harvesting p. custom/crew machine harvesting (custom combining, silage making, sugar beet lifting) q. poultry catching	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes	a. <input type="checkbox"/> Yes b. <input type="checkbox"/> Yes c. <input type="checkbox"/> Yes d. <input type="checkbox"/> Yes e. <input type="checkbox"/> Yes f. <input type="checkbox"/> Yes g. <input type="checkbox"/> Yes h. <input type="checkbox"/> Yes i. <input type="checkbox"/> Yes j. <input type="checkbox"/> Yes k. <input type="checkbox"/> Yes l. <input type="checkbox"/> Yes m. <input type="checkbox"/> Yes n. <input type="checkbox"/> Yes o. <input type="checkbox"/> Yes p. <input type="checkbox"/> Yes q. <input type="checkbox"/> Yes

	JOB 1	JOB 2	JOB 3	JOB 4
r. building cleaning	r. <input type="checkbox"/> Yes			
s. manure pumping	s. <input type="checkbox"/> Yes			
t. landscaping	t. <input type="checkbox"/> Yes			
27. During your work or chores, did you participate in any of the following activities?				
a. operating power machines, (e.g. tractors, combines) except motor vehicles	a. <input type="checkbox"/> Yes			
b. operating power hand tools	b. <input type="checkbox"/> Yes			
c. operating non-power hand tools/utensils/knives	c. <input type="checkbox"/> Yes			
d. lifting/bending/twisting	d. <input type="checkbox"/> Yes			
e. using chemicals	e. <input type="checkbox"/> Yes			
f. driving a car or truck	f. <input type="checkbox"/> Yes			
g. working with animals	g. <input type="checkbox"/> Yes			
h. climbing/working from heights	h. <input type="checkbox"/> Yes			
i. working around hot surfaces	i. <input type="checkbox"/> Yes			

INJURY/ACCIDENT EXPERIENCE

Please provide information on injuries or accidents that you have experienced. There are many different kinds of injuries: burns, broken bones, bruises, cuts, strains, sprains, or poisonings. This question asks about any injury or accident that:

- Restricted your normal activities for at least 4 hours;

AND/OR

- Resulted in a loss of consciousness, loss of awareness, or amnesia for any length of time;

AND/OR

- Caused you to seek professional health care, including care by doctors, nurses, chiropractors, dentists, or other healthcare professionals.

28. According to this definition, were you injured during September through May?

Yes

No **(SKIP TO page 9, question 36)**

Please fill in the following table describing any injuries that you experienced during **September through May**. We have provided you with space to describe four different injury events that may have occurred during SEPTEMBER THROUGH MAY. If you need additional space, please ask for more paper.

	INJURY1	INJURY 2	INJURY3	INJURY 4
29. Where did your injury or accident occur?	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity	① work/chore type (insert green work code from page 4) <input type="checkbox"/> <input type="checkbox"/> ② school ③ Other activity
30. In what month did your injury or accident occur?	① September ② October ③ November ④ December ⑤ January ⑥ February ⑦ March ⑧ April ⑨ May	① September ② October ③ November ④ December ⑤ January ⑥ February ⑦ March ⑧ April ⑨ May	① September ② October ③ November ④ December ⑤ January ⑥ February ⑦ March ⑧ April ⑨ May	① September ② October ③ November ④ December ⑤ January ⑥ February ⑦ March ⑧ April ⑨ May
31. What body part(s) were injured? (please mark all that apply).	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin	① Face/Nose ② Eyelid/Eye ③ Head/Scalp ④ Teeth ⑤ Shoulder ⑥ Arm/Elbow ⑦ Wrist/Hand/Finger ⑧ Upper Back/Neck ⑨ Mid/Lower Back ⑩ Hip/Leg ⑪ Ankle/Foot/Toe ⑫ Lungs ⑬ Ribs/Chest ⑭ Abdomen/Groin
32. What type of injury did you have?	① Bruise/abrasion ② Cut ③ Burn ④ Concussion/Loss of Consciousness			

	INJURY1	INJURY 2	INJURY3	INJURY 4
(please mark all that apply).	<ul style="list-style-type: none"> ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/ Dislocation ⑧ Chemical exposure ⑨ Other 	<ul style="list-style-type: none"> ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/ Dislocation ⑧ Chemical exposure ⑨ Other 	<ul style="list-style-type: none"> ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/ Dislocation ⑧ Chemical exposure ⑨ Other 	<ul style="list-style-type: none"> ⑤ Bite/Sting ⑥ Strain/Sprain ⑦ Fracture/ Dislocation ⑧ Chemical exposure ⑨ Other
33. Were you treated by any of the following as a result of this event? (please mark all that apply).	<ul style="list-style-type: none"> ① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment 	<ul style="list-style-type: none"> ① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment 	<ul style="list-style-type: none"> ① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment 	<ul style="list-style-type: none"> ① Physician ② Nurse/ Nurse Practitioner/ Physician's Asst. ③ Chiropractor ④ Dentist ⑤ Physical Therapist ⑥ No professional treatment
34. As a result of this injury or accident, how long were your normal activities restricted? Normal activities are things that you would expect to do on a regular basis.	<ul style="list-style-type: none"> ① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted 	<ul style="list-style-type: none"> ① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted 	<ul style="list-style-type: none"> ① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted 	<ul style="list-style-type: none"> ① Not restricted ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure/ activities still restricted
35. As a result of this injury or accident, have you had any permanent disabling problems?	<ul style="list-style-type: none"> ① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪ Chronic pain 	<ul style="list-style-type: none"> ① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪ Chronic pain 	<ul style="list-style-type: none"> ① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪ Chronic pain 	<ul style="list-style-type: none"> ① No permanent disabling problems ② Limited ability to use hand(s)/finger(s) ③ Loss of all or part of finger(s) ④ Loss of hand(s) ⑤ Loss of other body part ⑥ Hearing loss ⑦ Loss of sight, impaired sight ⑧ Limited ability to move arm(s) ⑨ Limited ability to move leg(s) ⑩ Scarring ⑪ Chronic pain

	INJURY1	INJURY 2	INJURY3	INJURY 4
36. How much school did you miss due to this injury or accident?	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure
37. How much work did you miss due to this injury or accident?	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure
38. How much work did your parent or guardian miss due to this injury or accident?	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure	① None ② 1 day or less ③ 1 day to 1 week ④ 8 days to 2 weeks ⑤ 15 days to 1 month ⑥ more than 1 month ⑦ Unsure

PERSONAL BEHAVIORS

39. During the past 12 months, how would you describe your grades in school?

- Mostly A's Mostly D's
 Mostly B's Mostly F's
 Mostly C's None of these
 Not sure

40. During September through May did you drive a motor vehicle (car, truck)?

- Yes
 No

41. How often do you wear a seat belt when riding in or driving a car?

- Always Rarely
 Sometimes Never

42. Have you ever used chewing tobacco, snuff, or dip?

- Yes
 No

43. Do you CURRENTLY smoke cigarettes?

- Yes
 No

A. If YES, during the past 30 days, on the days you smoked, how many cigarettes did you smoke per day?

- less than one cigarette per day
 1 cigarette per day
 2 to 5 cigarettes per day
 6 to 10 cigarettes per day
 11 to 20 cigarettes per day
 More than 20 cigarettes/day

B. During September through May did you smoke cigarettes?

- Yes
 No

44. At home, do people smoke cigarettes around you?

- Often Rarely
 Sometimes Never

45. Do your friends smoke cigarettes around you?

- Often Rarely
 Sometimes Never

46. If you work, do people smoke at your place of work?

- Often Rarely
 Sometimes Never

47. During September through May, on how many days did you have at least one drink of alcohol? *A drink is 1 can or bottle of beer, 1 glass of wine or wine cooler, 1 cocktail, or 1 shot.*

- 0 days
 1 or 2 days
 3 to 5 days
 6 to 9 days
 10 to 19 days
 20 to 29 days
 All 30 days

48. During September through May, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?

- 0 days
 1 or 2 days
 3 to 5 days
 6 to 9 days
 10 to 19 days
 20 or more days

49. What is your height? Please fill in the corresponding ovals below.

HEIGHT	
Feet	In.
③	①
④	①
⑤	②
⑥	③
⑦	④
	⑤
	⑥
	⑦
	⑧
	⑨
	⑩
	①①

50. What is your weight? Please fill in the corresponding ovals below.

WEIGHT IN POUNDS		
①	①	①
②	②	②
③	③	③
④	④	④
⑤	⑤	⑤
⑥	⑥	⑥
⑦	⑦	⑦
⑧	⑧	⑧
⑨	⑨	⑨

ASTHMA INFORMATION

51. Have you had wheezing or whistling in your chest in the past 12 months?

- Yes
 No

52. Have you had wheezing or whistling in your chest in the past 12 months when you exercise?

- Yes
 No

53. Has a doctor ever told you that you have asthma?

- Yes

- No ☞ **THANK YOU FOR COMPLETING THIS SURVEY. PLEASE TURN IN YOUR FORM.**

A. If YES, do you still have asthma?

- Yes
 No

B. If YES, is your asthma work-related?

- Yes
 No

54. Do you have a regular doctor or clinic where you go for asthma care?

- Yes
 No

55. Does your asthma bother you (check one)?

- Less than once a week
 About 2-3 times per week
 Almost every day

56. Do you have an Asthma Action Plan?

An Asthma Action Plan is a form with instructions about how to care for your asthma.

- Yes
 No

57. Do you have asthma medications that you take or inhale every day whether or not you have symptoms?

- Yes
 No

58. Do you have asthma medications that you take or inhale only when you have symptoms?

- Yes
 No

59. Do you have asthma medications that you take or inhale before you exercise?

- Yes
 No

60. During the past 30 days, how much time did you miss from the following activities due to asthma?

A. SCHOOL:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

B. WORK:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

C. ORGANIZED SPORTS:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

D. RECREATIONAL ACTIVITIES:

- None
 1 day or less
 2 days to 4 days
 5 days to 9 days
 10 days or more
 Don't know/unsure

THANK YOU FOR COMPLETING THIS SURVEY. PLEASE TURN IN YOUR FORM.