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The association of sleep duration and depressive symptoms in rural communities of southeastern Missouri, Tennessee, and Arkansas

Chang JJ[1], **Salas J**[1], **Habicht K**[2], **Pien GW**[3], **Stamatakis KA**[4], and **Brownson RC**[5]

[1]Department of Community Health in Epidemiology, Saint Louis University School of Public Health

[2]Center Disease Control CSTE Applied Epidemiology Fellowship Program at the Division of Acute Disease Epidemiology, South Carolina Department of Health and Environmental Control

[3]Sleep Medicine Division & Pulmonary, Allergy & Critical Care Division, Department of Medicine, University of Pennsylvania

[4]The Division of Public Health Sciences, Department of Surgery and Alvin J. Siteman Cancer Center, School of Medicine, Washington University in St. Louis.

[5]The Prevention Research Center in St Louis, the George Warren Brown School of Social Work, and the Department of Surgery and Alvin J. Siteman Cancer Center, School of Medicine, Washington University in St. Louis

Abstract

Purpose—To determine the association between sleep duration and depressive symptoms in a rural setting.

Methods—We conducted a cross-sectional study using data from Wave 3 of the Walk the Ozarks to Wellness Project including 12 rural communities in Missouri, Arkansas, and Tennessee (N = 1,204). Sleep duration was defined based on average weeknight and weekend hours per day: short (< 7), optimal (7-8), and long (> 8). The primary outcome was self-reported elevated depressive symptoms. Multivariable logistic regression was used to estimate adjusted prevalence odds ratios (aPOR) and 95% confidence intervals (95% CI).

Findings—Elevated depressive symptoms were common in this rural population (17%). Depressive symptoms were more prevalent among subjects with short (26.1%) and long (24%) sleep duration compared to those with optimal (11.8%) sleep duration. After adjusting for age, gender, race, education, employment status, income, and BMI, short sleep duration was associated with increased odds of elevated depressive symptoms (aPOR=2.12, 95% CI: 1.49, 3.01), compared to optimal sleep duration. Conversely, the association between long sleep duration and depressive symptoms was not statistically significant after covariate adjustment. Similar findings were observed when we excluded individuals with insomnia symptoms for analysis.

Conclusions—This study suggests that short sleep duration (<7 hours per night) and depressive symptoms are common among rural populations. Short sleep duration is positively associated with elevated depressive symptoms. The economic and healthcare burden of depression may be more overwhelming among rural populations, necessitating the need to target modifiable behaviors such as sleep habits to improve mental health.

Author for correspondence and reprint requests: Jen Jen Chang, PhD, Department of Community Health in Epidemiology, Saint Louis University School of Public Health, 3545 Lafayette Ave., Suite 300, St. Louis, MO 63104, Telephone: 314-977-8130, Fax: 314-977-3234, jjchang@slu.edu.

Keywords

Sleep duration; depression; rural communities

Introduction

Sleep plays an integral role in an individual's overall health and well being. Alvarez and Ayas have suggested that the optimal sleep duration associated with the lowest morbidity and mortality is 7-8 hours per night.[1] With the increasing demands of today's 24-hour society, restricted or disrupted sleep (< 7 hours per 24 hours) is a widespread and serious public health problem. According to the 2009 National Sleep Foundation Survey, Americans sleep an average of 6.7 hours a night, with approximately 23% sleeping less than 7 hours per 24 hours.[2] In addition, the proportion of Americans sleeping less than 6 hours per 24 hours has been increasing from 12% in 1998 to 20% in 2009.[2] Prior research has indicated that short sleep duration is more common among individuals who are black, of low socioeconomic status, older, unmarried, who care for young children, work long hours, report alcohol use, or are overweight/obese.[3,4]

Sleep durations that are longer or shorter than 7-8 hours in a 24-hour period are associated with acceleration of the aging process,[5] increased risk of impaired glucose tolerance, diabetes,[6,7] obesity, [8] hypertension,[9] injuries,[10] and increased mortality.[11,12] In addition, short sleep duration adversely affects cognitive performance, learning, memory, and mental health.[13-19] Although disrupted sleep or short sleep duration associated with psychiatric disorders is usually considered as a symptom of the disease, several studies have indicated that the relationship between sleep duration and mood disorders is more complex and may be bi-directional.[20,21] Instead of being a symptom, sleep duration may be a causal factor in the development of mood disorders.[20,21]

Experimental studies in rats showed that chronic short sleep duration resulted in alterations in neurotransmitter systems (e.g., serotonin and corticotropin-releasing hormone receptor systems) that have been similarly reported among individuals diagnosed with major depression.[22,23] Studies of adolescent populations have reported that teens with short sleep duration were 24% more likely to be depressed and up to three times more likely to exhibit suicidal ideation or behavior.[24,25] Similarly, studies in adult populations have found that shorter sleep duration was indicative of depressive symptoms and carried a 5-fold increased hazard of depression recurrence. [20, 26] Thus, while sleep disturbances are often hallmark symptoms of depressive disorders, they may also be risk factors for the development or exacerbation of depressive symptomatology.[20,26,27]

Depressive disorders are associated with substantial impairment, comorbidity, poor health, and mortality.[28,29] The estimated prevalence of depressive symptoms in the US is approximately 8.7% and the lifetime prevalence of the diagnosis of depression is 15.7%.[30] The prevalence of current major depressive disorder is approximately 5.3%,[29] with rural populations having a higher prevalence than urban populations (6.1% vs. 5.2%, respectively).[31] Rural residents are a medically vulnerable population with reduced access to healthcare services.[32] They have an increased risk of health problems, such as diabetes, cardiovascular disease, obesity, and traumatic injuries.[32] The greater proportion of people with poor health in rural population places them at higher risk for depression.[31] Thus, the disabilities and impairments associated with depression may be of even greater concern in rural populations.

While a link exists between sleep duration and depression, with short sleep duration as a plausible risk factor for depressive symptoms,[12,20,22-26] this association is less established among a rural, adult population. Rural populations not only have unique demographics and lifestyles, but also unique health needs.[32] Compared with urban and suburban dwellers, rural residents are more commonly employed in agriculture and small business.[33] Poverty rates are higher in rural areas compared to their metropolitan counterparts.[34] About one-fourth of older Americans live in rural areas and small towns, yet half of older Americans with poverty-level incomes live in such areas.[35] Rural residents are also more socially isolated, less likely to work in white collar occupations, live in substandard housing, have lower education levels, and less adequate access to health services.[34] All of the aforementioned factors could contribute to negative health outcomes, as evident in the rural health disparities in heart disease, physical inactivity, alcohol abuse and tobacco dependence, and psychiatric symptoms.[32,34,36]

Recent studies have focused on the increased risk for obesity due to short sleep duration in rural populations,[37,38] yet the higher prevalence of current major depressive disorder highlights the need to examine how sleep duration may also relate to depressive symptoms in this population. [31] The present study was conducted to examine the relationship between sleep duration and depressive symptoms, using data from 12 rural communities in Missouri, Tennessee, and Arkansas involved in the Walk the Ozarks to Wellness Project.

Methods

Study Design

This cross-sectional study assessed the relationship between sleep duration and depressive symptoms in a rural population using data from the Walk the Ozarks to Wellness Project. The details of the this longitudinal study have been previously described, but a brief description follows.[39] The Walk the Ozarks to Wellness Project was a four year, quasi-experimental longitudinal study of an intervention to increase walking behaviors in 12 rural communities in Missouri, Tennessee, and Arkansas. Of the 12 communities identified for this study, seven had populations of less than 2500 persons, two were between 2500 and 10,000 persons, and three had populations between 10,000 and 20,000 persons. Compared with the rest of Missouri and the United States, this region has significantly more poverty, is medically underserved, and has lower educational levels. Death rates for chronic diseases (i.e., heart disease, stroke, cancer, diabetes) were significantly higher in the 5-county intervention area (age-adjusted rate = 653 per 100,000) than in Missouri (602 per 100,000) for the period 1993–2002.[39]

Study participants included individuals from six intervention communities in the Missouri Ozark region and six comparison communities in Arkansas (n=2) and Tennessee (n=4), matched based on size, race/ethnicity, and income level. Data were obtained by telephone interviews using an instrument based on the Behavioral Risk Factor Surveillance questionnaire. Eligible households were those within a 2-mile radius of walking trails and they were contacted via random-digit dialing. Data pertinent to this study was used from the third wave of data collection (July to September 2005) because of the inclusion of sleep habits in this phase of data collection (n=1,258).[38] Response rate for this wave of data collection was 65.2%. This study was granted exemption by the Saint Louis University Institutional Review Board.

Measures

Sleep duration—Respondents were asked “How many hours of sleep do you usually get at night (or your main sleep period)?” on weekdays or workdays as well as on weekend or

non-working days. They were allowed an open-ended response, rounded to the nearest hour. Sleep duration for this analysis is based on the average of the reported sleep hours for both weekdays and weekends. Responses were grouped into a categorical sleep duration variable: 1) less than 7 hours was categorized as short sleep duration; 2) 7-8 hours as optimal; and 3) more than 8 hours as long sleep duration. This measure has been reported to be stable over time (r = 0.57 for 2.4 years) and to exhibit face validity.[38]

Depressive symptoms—The presence of depressive symptoms was assessed from the Patient Health Questionnaire – 2 (PHQ-2).[40] Participants were asked how often in the last two weeks they had experienced the following: 1) "Little interest or pleasure in doing things?" and 2) "Feeling down, depressed, or hopeless?" Response choices for each question were rated on a scale from 0 ('not at all') to 3 ('nearly every day'), with total depressive symptom scores ranging from 0 to 6. If the total score was 3 or greater, participants were categorized as having elevated depressive symptoms. Otherwise, participants were categorized as having no elevated depressive symptoms. Kroenke and colleagues reported good criterion validity using a cut-point of 3 or above when compared to a mental health professional interview.[40] Areas under the curves for major or any depressive disorder were found to range between 0.90 and 0.93, with 83% sensitivity and 90% specificity.[40] Adequate construct validity was also established as there were strong associations between PHQ-2 scores and depression-related disabilities and difficulties. [40]

Covariates—Factors associated with both sleep duration and depressive symptoms were evaluated as potential confounders in this study. Sociodemographic factors included: age (continuous); gender; race/ethnicity (White, non-Hispanic versus Other); income (<$20,000, $20 to <$35,000, $35 to <$75,000, and $75,000+); employment status defined as employed (employed for wages or self-employed), non-wage earner (student, homemaker, out of work more than one year, or out of work less than one year), retired, and unable to work; and education (less than high school, high school graduate, more than high school). Behavioral characteristics included: current smoking status (smoker versus non-smoker) and physical activity (e.g. running, calisthenics, walking) in the last month, other than for a regular job. Health indicators were body mass index (BMI, continuous); self-reported history of any chronic disease (answering yes to any of the following conditions: heart disease, kidney disease, diabetes, high blood sugar, hypertension, cholesterol, or arthritis); and self-reported history of cancer. Lastly, individuals were categorized as having insomnia if they had experienced all three of the following symptoms at least five times per month: 1) "Having trouble falling asleep"; 2) "Wake up during the night and have difficulty getting back to sleep"; and 3) "Wake up too early in the morning and are unable to get back to sleep".[38]

Statistical Analyses

Fifty-four individuals (4.5%) were excluded from analyses because of missing data on exposure, outcome or covariates, resulting in a final study sample size of 1,204 for analysis. Bivariate analyses showed that those who were included in analyses were similar to those excluded from analyses in terms of covariate characteristics, sleep duration, and depressive symptoms. Our power analysis indicated adequate statistical power (power = .95) in detecting a previously reported bivariate effect between short sleep duration and outcome (an effect size of odds ratio of 1.8) and marginal power to detect an odds ratio of 2.2 between long sleep duration and outcome (power = .80) at an alpha level of 0.05.[38]

Statistical tests of bivariate associations between sleep duration (< 7 hours, 7-8 hours, and 9 or more hours per night) and covariates were based on a χ^2 distribution for categorical data and a one way ANOVA for continuous covariates (i.e., age and body mass index). Crude prevalence odds ratios (cPOR) and 95% confidence intervals (CI) for the relationship

between sleep duration and elevated depressive symptoms were estimated using a simple logistic regression model, with optimal sleep duration (7-8 hours per night) as the referent. A multiple logistic regression model was used to estimate adjusted prevalence odds ratios (aPOR) and 95% confidence intervals adjusting for confounders. Backwards elimination modeling was used to evaluate potential confounders using 10% change-in-estimate rule[41]; potential confounders evaluated included age, gender, race, education, employment status, income, BMI, history of chronic disease, cancer, any exercise in the last month, and current smoking status. If the removal of a covariate changed the aPOR by 10% or greater, it was retained in the final model.[41] Because insomnia complaints are common symptoms of depression[14] and have been shown to increase the risk of depressive episodes,[15,16,26] we also conducted a subsample analysis among subjects without insomnia symptoms (n = 1, 042). All analyses were conducted using SAS, Version 9.2 (SAS version 9.2, SAS Inc., Cary, North Carolina).

Results

The overall prevalence of elevated depressive symptoms (PHQ 2 ≥ 3) in this sample was 17.1%. The average sleep duration in this rural population is 6.9 hours (SD=1.30) and 7.4 hours (SD=1.44) for weekdays and weekends, respectively. Based on the average sleep duration for both weekdays and weekends, the proportion of study subjects who reported sleeping <7 hours per night (short sleep duration), 7-8 hours per night (optimal sleep duration), and >8 hours per night (long sleep duration) was 29.7%, 61.7%, and 8.6%, respectively. Individual with short sleep duration were more likely to be high school graduates whereas those with long sleep duration were more likely to have less than high school education, to have lower income levels, to be unemployed/retired/unable to work, and to be current smokers, compared to other participants in the study (Table 1). Study participants did not differ by race, gender, age, BMI, or histories of chronic disease and cancer by sleep duration.

Bivariate analysis indicated a U-shape association between sleep duration and elevated depressive symptoms. Specifically, compared to participants with optimal sleep duration, the crude prevalence odds of elevated depressive symptoms were 2.62 (95% CI: 1.90, 3.63) and 2.36 (95% CI: 1.43, 3.89) for short and long sleep duration, respectively. After adjusting for age, gender, race, education, employment status, income, and BMI, short sleep duration was still associated with increased odds of elevated depressive symptoms (aPOR=2.12, 95% CI: 1.49, 3.01, Table 2), compared to optimal sleep duration. Conversely, after controlling for confounders, long sleep duration was no longer associated with elevated depressive symptoms (aPOR = 1.62, 95% CI: 0.92, 2.85). Lower level of education (i.e., < high school), lower income (< $20,000, and higher BMI were also significantly associated with elevated depressive symptoms (Table 2).

Clinical and epidemiological studies have shown that sleep disturbances such as insomnia are closely linked to major depression.[42,43] Therefore, we conducted a sub-analyses on participants without insomnia symptoms for the relationship between sleep duration and depressive symptoms (n= 1,042). Table 3 indicated that after excluding individuals with insomnia symptoms, there was still a statistically significant association between short sleep duration and elevated depressive symptoms, compared to those with optimal sleep duration, after controlling for confounders (aPOR = 1.95, 95% CI: 1.28, 2.98). As in analyses including subjects with and without insomnia, Long sleep duration was not associated with elevated depressive symptoms in the adjusted model (aPOR = 1.74, 95% CI: 0.94, 3.20).

Discussion

This investigation provides preliminary evidence of an association between sleep duration and elevated depressive symptoms in rural populations. After adjusting for sociodemographic factors (i.e. age, race, gender, income, education and employment status) and BMI, short sleep duration was associated with elevated depressive symptoms. Sleep disturbances such as insomnia are also risk factors and symptoms of depression.[14] After excluding individuals with insomnia symptoms, we continued to observe a statistically significant association between short sleep duration and elevated depressive symptoms. Increased odds of elevated depressive symptoms were observed among those with long sleep duration compared to those with optimal sleep duration. However, this association was not statistically significant after adjusted for confounders.

In a prospective cohort study, Ganguli and associates observed that sleep complaints and short sleep duration were common among older rural residents.[44] Sleep problems among the rural residents are sometimes associated with treatable health conditions and modifiable behavioral and environmental characteristics. However, compared to their urban counterparts, individuals from rural communities have access to a smaller number and narrower range of health care providers and services and are less likely to be using these health services.[45] Hence, it is unlikely that specialized sleep medicine services are available outside major metropolitan areas to rural residents to receive the needed care in addressing their sleep complaints.

Furthermore, rural communities are exposed to circumstances, conditions, and behaviors that may put them at greater risk for depression.[36] These include physical inactivity, heavy alcohol consumption, fewer regular dental visits, and higher incidences of chronic illness when compared with urban residents.[31,46] Previous studies have reported that rural areas have a disproportionate share of individuals at risk of poor mental health (e.g. the elderly the chronically ill).[47,48] Furthermore, rural residents are more commonly employed in agriculture settings which are characterized by a range of physical, biological, chemical and mechanical hazards.[49] And prior research has found higher rates of depression and anxiety among farmers than the general population.[50,51] However, rural areas are generally lacking in both the level and quality of mental health services[47,48]. Access to mental health services and concern for suicide stress depression and anxiety disorders were identified as major rural health concerns among state offices of rural health.[52] Marvin and colleagues had reported that the proportion of counties that are whole-county shortage areas for mental health professionals increases from 37% among large rural counties adjacent to metropolitan areas to 76% among isolated small rural counties.[53] Therefore, it may be difficult for rural residents to obtain specialist care for depression. Taken together, these features of rural life and culture may have bearing on the relationship between short sleep duration and depression in rural communities different from the urban communities.

Although prior research is scant in similar populations, our findings on short sleep duration in this rural population are consistent with previous findings.[20,24,26] In a large cross-sectional study of Korean adults aged 18-64, Park and colleagues found that sleeping 5 hours or less per night was associated with mood disorders.[3] Studies on pilots and officers after night duty observed that there was an increase in self-reported feelings of depressed mood, anger, frustration, tension, and anxiety during prolonged sleep deprivation.[54,55] In a small longitudinal study of patients with bipolar disorder who were free of affective disorders at baseline, Perlman and colleagues reported that shorter sleep duration predicted increased depressive symptoms over the subsequent 6 months follow-up.[20] Even though sleep disturbances are possibly a trait marker of depression, the medical literature is inconsistent on the directionality of this association.[56,57] Paradoxically, among individuals

with mood disorders, sleep restriction can also have an antidepressant effect, [58] underscoring the complex interaction between sleep duration and normal affect regulation.

Prior epidemiological investigations have indicated that sleep duration and mortality have a U-shaped relationship.[1,11,59,60] In a sample from the National Women's Health Initiative, both short and long sleep duration as compared to optimal sleep duration increased the incidence of depression.[61] After adjusting for covariates, our data did not support as robust a statistical association between longer sleep duration (> 8 hours per night) and elevated depressive symptoms as short sleep duration. The discrepancy in findings among studies may also be attributed to different definitions and assessment of sleep duration and depressive symptoms. Alternatively, the observed crude association between long sleep duration with elevated depressive symptoms in our study may be attributed to the socioeconomic risk factors for which we adjusted in our multivariable analysis (i.e. age, gender, race, education, employment status, income, and BMI).

Animal studies found that when subjected to chronic sleep restriction, neurotransmitter receptor systems (e.g. serotonin-1A and corticotropin-releasing hormone receptor systems[22]; serotonin 5-HT dysregulation[23]) and neuroendocrine stress reactivity (e.g. the HPA axis[22]) were gradually altered in similar fashions to individuals diagnosed with major depression. In human samples, increased hypothalamic-pituitary-adrenocortical (HPA) activity as well as reduced growth hormone secretion have also been found in untreated depressive patients and normal individuals with altered sleep patterns.[62] In other words, altered sleep architecture due to short sleep duration can alter chemical pathways that have been implicated in depressive patients.

Some limitations in the present study warrant mention. The direction of causality in the relationship between sleep duration and depressive symptoms cannot be established in this cross-sectional study, nor are the reasons underlying short sleep duration in our participants known. Selection bias may be present with a response rate of 65.2% in our study, with participants likely having healthier lifestyles than those not enrolled in the study. Our findings were also based on self-report data including sleep duration and depressive symptoms. Measurement error in sleep duration is possible due to lack of objective assessment of sleep duration. However, self-reported sleep duration has been found to reliably predict prospective mortality and other health outcomes.[9,11,12,63] The PHQ-2 is a valid, brief screening measure for probable clinical depression but is not a diagnostic criteria-based assessment tool for clinical depression. Lastly, our data also did not provide clinical measures of medical conditions or information on shift work, caffeine and alcohol consumption, medication usage, or prior history of depressive disorder.[26,59,62,64] Results from our study may not be generalizable to urban or suburban populations since our sample was drawn from a poor rural population.

This study suggests that short sleep duration (<7 hours per night) and depressive symptoms are common among rural populations in Missouri, Arkansas, and Tennessee. Furthermore, short sleep duration is positively associated with elevated depressive symptoms. It is estimated that the yearly economic burden of depression in the United States is approximately $83.1 billion.[65] These burdens may be of greater consequence for rural populations, as they are likely poorer, less health literate, and have inadequate access to health care, especially primary and specialty care.[64,66] Provisions could allow for improved understanding of reasons underlying short sleep duration in rural residents, as these may differ between rural and urban populations. In turn, this could lead to greater screening and preventive efforts or interventions targeted at rural residents, to avoid undue morbidity associated with depression, and interventions could focus on altering lifestyle choices to improve sleep habits and overall well-being. More research is needed to understand the risk

factors associated with short sleep duration in rural communities to facilitate targeted interventions. Future prospective studies are needed to confirm our findings on the association between short sleep duration and depressive symptoms in rural populations.

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Reference

1. Alvarez GG, Ayas NT. The impact of daily sleep duration on health: a review of the literature. Prog Cardiovasc Nurs. 2004 Spring;19(2):56–59. [PubMed: 15133379]
2. National Sleep Foundation. Summary of Findings: 2009 Sleep in America Poll. Washington, DC: Mar 2. 2009
3. Park S, Cho MJ, Chang SM, et al. Relationships of sleep duration with sociodemographic and health-related factors, psychiatric disorders and sleep disturbances in a community sample of Korean adults. J Sleep Res. Dec; 2010 19(4):567–577. [PubMed: 20477953]
4. Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. Am J Epidemiol. May 1; 2009 169(9):1052–1063. [PubMed: 19299406]
5. Copinschi G. Metabolic and endocrine effects of sleep deprivation. Essent Psychopharmacol. 2005; 6(6):341–347. [PubMed: 16459757]
6. Van Cauter E, Holmback U, Knutson K, et al. Impact of sleep and sleep loss on neuroendocrine and metabolic function. Horm Res. 2007; 67(Suppl 1):2–9. [PubMed: 17308390]
7. Ayas NT, White DP, Al-Delaimy WK, et al. A prospective study of self-reported sleep duration and incident diabetes in women. Diabetes Care. Feb; 2003 26(2):380–384. [PubMed: 12547866]
8. Leproult R, Van Cauter E. Role of Sleep and Sleep Loss in Hormonal Release and Metabolism. Endocr Dev. 2010; 17:11–21. [PubMed: 19955752]
9. Gottlieb DJ, Redline S, Nieto FJ, et al. Association of usual sleep duration with hypertension: the Sleep Heart Health Study. Sleep. Aug 1; 2006 29(8):1009–1014. [PubMed: 16944668]
10. Choi SW, Peek-Asa C, Sprince NL, et al. Sleep quantity and quality as a predictor of injuries in a rural population. Am J Emerg Med. Mar; 2006 24(2):189–196. [PubMed: 16490649]
11. Kripke DF, Garfinkel L, Wingard DL, Klauber MR, Marler MR. Mortality associated with sleep duration and insomnia. Arch Gen Psychiatry. Feb; 2002 59(2):131–136. [PubMed: 11825133]
12. Patel SR, Ayas NT, Malhotra MR, et al. A prospective study of sleep duration and mortality risk in women. Sleep. May 1; 2004 27(3):440–444. [PubMed: 15164896]
13. Chang PP, Ford DE, Mead LA, Cooper-Patrick L, Klag MJ. Insomnia in young men and subsequent depression. The Johns Hopkins Precursors Study. Am J Epidemiol. Jul 15; 1997 146(2):105–114. [PubMed: 9230772]
14. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. Fourth Edition. American Psychiatric Association; Washington, DC: 2000. Text Revision
15. Benca RM. Consequences of insomnia and its therapies. J Clin Psychiatry. 2001; 62(Suppl 10):33–38. [PubMed: 11388589]
16. Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. Semin Neurol. Mar; 2005 25(1):117–129. [PubMed: 15798944]
17. Ford DE, Kamerow DB. Epidemiologic study of sleep disturbances and psychiatric disorders. An opportunity for prevention? JAMA. Sep 15; 1989 262(11):1479–1484. [PubMed: 2769898]
18. Livingston G, Blizard B, Mann A. Does sleep disturbance predict depression in elderly people? A study in inner London. Br J Gen Pract. Nov; 1993 43(376):445–448. [PubMed: 8292414]
19. Pilcher JJ, Huffcutt AI. Effects of sleep deprivation on performance: a meta-analysis. Sleep. May; 1996 19(4):318–326. [PubMed: 8776790]

20. Perlman CA, Johnson SL, Mellman TA. The prospective impact of sleep duration on depression and mania. Bipolar Disord. Jun; 2006 8(3):271–274. [PubMed: 16696829]
21. Taylor DJ. Insomnia and depression. Sleep. Apr 1; 2008 31(4):447–448. [PubMed: 18457230]
22. Novati A, Roman V, Cetin T, et al. Chronically restricted sleep leads to depression-like changes in neurotransmitter receptor sensitivity and neuroendocrine stress reactivity in rats. Sleep. Nov 1; 2008 31(11):1579–1585. [PubMed: 19014078]
23. Roman V, Walstra I, Luiten PG, Meerlo P. Too little sleep gradually desensitizes the serotonin 1A receptor system. Sleep. Dec 1; 2005 28(12):1505–1510. [PubMed: 16408408]
24. Gangwisch JE, Babiss LA, Malaspina D, Turner JB, Zammit GK, Posner K. Earlier parental set bedtimes as a protective factor against depression and suicidal ideation. Sleep. 2010; 33(1):97–106. [PubMed: 20120626]
25. Liu X. Sleep and adolescent suicidal behavior. Sleep. Nov 1; 2004 27(7):1351–1358. [PubMed: 15586788]
26. Cho HJ, Lavretsky H, Olmstead R, Levin MJ, Oxman MN, Irwin MR. Sleep disturbance and depression recurrence in community-dwelling older adults: a prospective study. Am J Psychiatry. Dec; 2008 165(12):1543–1550. [PubMed: 18765482]
27. Kahn-Greene ET, Killgore DB, Kamimori GH, Balkin TJ, Killgore WD. The effects of sleep deprivation on symptoms of psychopathology in healthy adults. Sleep Med. Apr; 2007 8(3):215–221. [PubMed: 17368979]
28. Wells KB, Stewart A, Hays RD, et al. The functioning and well-being of depressed patients. Results from the Medical Outcomes Study. JAMA. Aug 18; 1989 262(7):914–919. [PubMed: 2754791]
29. Hasin DS, Goodwin RD, Stinson FS, Grant BF. Epidemiology of major depressive disorder: results from the National Epidemiologic Survey on Alcoholism and Related Conditions. Arch Gen Psychiatry. Oct; 2005 62(10):1097–1106. [PubMed: 16203955]
30. Strine TW, Mokdad AH, Dube SR, et al. The association of depression and anxiety with obesity and unhealthy behaviors among community-dwelling US adults. Gen Hosp Psychiatry. Mar-Apr; 2008 30(2):127–137. [PubMed: 18291294]
31. Probst, J.; Laditka, S.; Moore, C.; Harun, N.; Powell, M. Depression in rural populations: Prevalence, effects on life quality, and treatment-seeking behavior. South Carolina Rural Health Research Center; Columbia, SC: 2005.
32. Hartley D. Rural health disparities, population health, and rural culture. Am J Public Health. Oct; 2004 94(10):1675–1678. [PubMed: 15451729]
33. Myers JR. National surveillance of occupational fatalities in agriculture. Am J Ind Med. 1990; 18(2):163–168. [PubMed: 2169704]
34. Eggebeen DJ, Lichter DT. Health and well-being among rural Americans: variations across the life course. J Rural Health. 1993 Spring;9(2):86–98. [PubMed: 10126239]
35. Glasgow N, Beale CL. Rural elderly in demographic perspectives. Rural Development Perspectives. 1985; 2(1):22–26.
36. Probst JC, Laditka SB, Moore CG, Harun N, Powell MP, Baxley EG. Rural-urban differences in depression prevalence: implications for family medicine. Fam Med. Oct; 2006 38(9):653–660. [PubMed: 17009190]
37. Kohatsu ND, Tsai R, Young T, et al. Sleep duration and body mass index in a rural population. Arch Intern Med. Sep 18; 2006 166(16):1701–1705. [PubMed: 16983047]
38. Stamatakis KA, Brownson RC. Sleep duration and obesity-related risk factors in the rural Midwest. Prev Med. May; 2008 46(5):439–444. [PubMed: 18155130]
39. Brownson RC, Hagood L, Lovegreen SL, et al. A multilevel ecological approach to promoting walking in rural communities. Prev Med. Nov-Dec;2005 41(5-6):837–842. [PubMed: 16256183]
40. Kroenke K, Spitzer RL, Williams JB. The Patient Health Questionnaire-2: validity of a two-item depression screener. Med Care. Nov; 2003 41(11):1284–1292. [PubMed: 14583691]
41. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. Am J Epidemiol. Dec 1; 1993 138(11):923–936. [PubMed: 8256780]

42. Staner L. Comorbidity of insomnia and depression. Sleep Med Rev. Feb; 2010 14(1):35–46. [PubMed: 19939713]
43. Hartz AJ, Daly JM, Kohatsu ND, Stromquist AM, Jogerst GJ, Kukoyi OA. Risk factors for insomnia in a rural population. Ann Epidemiol. Dec; 2007 17(12):940–947. [PubMed: 17937993]
44. Ganguli M, Reynolds CF, Gilby JE. Prevalence and persistence of sleep complaints in a rural older community sample: the MoVIES project. J Am Geriatr Soc. Jul; 1996 44(7):778–784. [PubMed: 8675924]
45. Coward, RT.; McLaughlin, DK.; Duncan, RP.; Bull, CN. An overview of health and aging in rural America. In: Coward, Rt; Bull, CN.; Kukulka, G.; Galliher, JM., editors. Health Services for Rural Elders. Springer; New York: 1994. p. 1-32.
46. Mulder, PL.; Shellenberger, S.; Streiegel, R., et al. [Accessed July 25, 2011] The behavioral health care needs of rural women. 2000. http://www.apa.org/pubs/info/reports/rural-women.pdf
47. Human J, Wasem C. Rural mental health in America. Am Psychol. Mar; 1991 46(3):232–239. [PubMed: 2035933]
48. Wagenfeld MO. Mental health and rural America: a decade review. J Rural Health. Oct; 1990 6(4): 507–522. [PubMed: 10107687]
49. Fraser CE, Smith KB, Judd F, Humphreys JS, Fragar LJ, Henderson A. Farming and mental health problems and mental illness. Int J Soc Psychiatry. Dec; 2005 51(4):340–349. [PubMed: 16400909]
50. Eisner CS, Neal RD, Scaife B. The effect of the 1996 ‘beef crisis’ on depression and anxiety in farmers and non-farming controls. Br J Gen Pract. May; 1999 49(442):385–386. [PubMed: 10736890]
51. Sanne B, Mykletun A, Moen BE, Dahl AA, Tell GS. Farmers are at risk for anxiety and depression: the Hordaland Health Study. Occup Med (Lond). Mar; 2004 54(2):92–100. [PubMed: 15020727]
52. State Office of Rural health Research Interests Survey Results; National Rural health Research Center Director’s Meeting; Washington, DC. March 5, 2011;
53. Merwin E, Hinton I, Dembling B, Stern S. Shortages of rural mental health professionals. Arch Psychiatr Nurs. Feb; 2003 17(1):42–51. [PubMed: 12642887]
54. Orton DI, Gruzelier JH. Adverse changes in mood and cognitive performance of house officers after night duty. BMJ. Jan 7; 1989 298(6665):21–23. [PubMed: 2492842]
55. Caldwell JA, Caldwell JL, Brown DL, Smith JK. The effects of 37 h of continuous wakefulness on the physiological arousal, congnitive performance, self-reported mood, and simulator flight performance of F-117A pilots. Millitary Psychology. 2004; 16:163–181.
56. Modell S, Ising M, Holsboer F, Lauer CJ. The Munich Vulnerability Study on Affective Disorders: stability of polysomnographic findings over time. Biol Psychiatry. Sep 1; 2002 52(5):430–437. [PubMed: 12242059]
57. Leistedt S, Dumont M, Coumans N, Lanquart JP, Jurysta F, Linkowski P. The modifications of the long-range temporal correlations of the sleep EEG due to major depressive episode disappear with the status of remission. Neuroscience. Sep 7; 2007 148(3):782–793. [PubMed: 17693033]
58. Wu JC, Bunney WE. The biological basis of an antidepressant response to sleep deprivation and relapse: review and hypothesis. Am J Psychiatry. Jan; 1990 147(1):14–21. [PubMed: 2403471]
59. Stamatakis KA, Punjabi NM. Long sleep duration: a risk to health or a marker of risk? Sleep Med Rev. Oct; 2007 11(5):337–339. [PubMed: 17854737]
60. Grandner MA, Drummond SP. Who are the long sleepers? Towards an understanding of the mortality relationship. Sleep Med Rev. Oct; 2007 11(5):341–360. [PubMed: 17625932]
61. Kripke DF, Brunner R, Freeman R, et al. Sleep complaints of postmenopausal women. Clin J Wom Health. 2001; 1(5):244–252.
62. Riemann D, Berger M, Voderholzer U. Sleep and depression--results from psychobiological studies: an overview. Biol Psychol. Jul-Aug;2001 57(1-3):67–103. [PubMed: 11454435]
63. Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: analyses of the NHANES I. Sleep. Oct 1; 2005 28(10):1289–1296. [PubMed: 16295214]

64. Stamatakis KA, Kaplan GA, Roberts RE. Short sleep duration across income, education, and race/ethnic groups: population prevalence and growing disparities during 34 years of follow-up. Ann Epidemiol. Dec; 2007 17(12):948–955. [PubMed: 17855122]

65. Greenberg PE, Kessler RC, Birnbaum HG, et al. The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry. Dec; 2003 64(12):1465–1475. [PubMed: 14728109]

66. Gamm, LD.; Hutchison, LL. Rural Healthy People 2010: A Companion Document to Healthy People 2010. Vol. 3. The Texas A&M University System Health Science Center, School of Rural Public Health, Southwest Rural Health Research Center; College Station, TX: 2004.

Table 1

Study sample characteristics by sleep duration, Walk the Ozarks to Wellness Project, Wave 3, Rural Midwest (n = 1,204)

Variable	Short Sleep (n = 357) %	Optimal Sleep (n = 743) %	Long Sleep (n = 104) %	*P*-value[a]
Education				0.01
< High School	13.2	9.6	21.2	
High School Graduate or GED	31.4	29.7	28.9	
More than High School	55.5	60.7	50.0	
Income				<0.05
< $20,000	34.2	21.1	35.6	
$20 to < $35,000	24.7	21.3	27.9	
$35 to < $75,000	26.9	34.5	19.2	
$75,000+	14.3	23.2	17.3	
Race				0.11
White	93.3	96.1	96.2	
Other, non-White	6.7	3.9	3.9	
Gender (Male)	23.3	23.5	22.9	0.92
Employment Status				<0.05
Employed	44.5	48.9	26.9	
Non-wage earner	13.5	16.0	18.3	
Retired	24.9	26.7	26.9	
Unable to work	17.1	8.5	27.9	
Mean Age (SD) (years)	51.4(15.8)	52.4(16.0)	51.4(16.1)	0.17
Current Smoker (yes)	23.0	17.1	28.9	< 0.05
Physical Activity in Last Month (yes)	71.2	77.7	71.2	0.04
Mean (SD) BMI	28.3 (6.9)	27.7 (6.4)	28.0 (6.8)	0.19
Any Chronic Disease (yes)	71.4	69.6	71.2	0.80
History of Cancer (yes)	11.2	13.6	14.4	0.49

[a]Two-tailed *P*-values based on χ^2 distribution for categorical data and an ANOVA for continuous covariates

Table 2

Adjusted Prevalence Odds Ratios and 95% Confidence Intervals for having elevated depressive symptoms

Variable	APOR	95% CI
Sleep Duration (ref: Optimal)		
Short	2.12	1.49, 3.01
Long	1.62	0.92, 2.85
Age	1.00	0.99, 1.01
Gender (ref: Female)		
Male	0.86	0.57, 1.32
Race (ref: White)		
Non-white	1.07	0.51, 2.24
Education (ref: > High School)		
< High School	1.75	1.06, 2.90
High School Grad or GED	1.31	0.88, 1.94
Income (ref: ≥ $75,000)		
< $20,000	5.35	2.67, 10.70
$20,000 -< $35,000	2.00	0.99, 4.02
$35,000 -< $75,000	1.47	0.75, 2.88
Employment (ref: Wage Earner)		
Non Wage Earner	0.68	0.39, 1.18
Retired	0.83	0.47, 1.47
Unable to Work	1.65	0.99, 2.75
BMI	1.04	1.02, 1.07

[a]APOR = Adjusted Prevalence Odds Ratio; CI = 95% Confidence Interval

Table 3

Adjusted Prevalence Odds Ratios and 95% Confidence Intervals for having elevated depressive symptoms among participants without insomnia symptoms (n = 1, 042)[a]

Variable	APOR	95% CI
Sleep Duration (ref: Optimal)		
Short	1.95	1.28, 2.98
Long	1.74	0.94, 3.20
Age	1.00	0.98, 1.02
Gender (ref: Female)		
Male	0.89	0.55, 1.43
Race (ref: White)		
Non-white	0.87	0.34, 2.21
Education (ref: > High School)		
< High School	1.78	0.97, 3.25
High School Grad or GED	1.27	0.80, 2.00
Income (ref: ≥ $75,000)		
< $20,000	5.58	2.52, 12.33
$20,000 -< $35,000	50	1.08, 5.23
$35,000 -< $75,000	1.48	0.70, 3.23
Employment (ref: Wage Earner)		
Non Wage Earner	0.75	0.40, 1.41
Retired	0.81	0.43, 1.55
Unable to Work	1.24	0.66, 2.32
BMI	1.04	1.01, 1.06

[a]APOR = Adjusted Prevalence Odds Ratio; CI = 95% Confidence Interval