*** Prepared for submission to PAA 2009 – Please do not cite or quote ***

SLEEP DURATION AND MORTALITY RISK: DO SOCIAL FACTORS MODERATE THE RELATIONSHIP?*

Jennifer Ailshire
Department of Sociology
University of Michigan

Sarah A. Burgard
Departments of Sociology and Epidemiology and Population Studies Center
University of Michigan

September 2008

Total Word Count: 4,436 including abstract, text, and references but not tables
Number of Tables: 3
Number of Figures: 1
Running Head: Sleep and Mortality

Acknowledgements: The authors were supported by core funding from the Eunice Kennedy Shriver National Institute of Child Health & Human Development (R24 HD041028) and the National Institute on Aging (P30 AG012846-14) to the Population Studies Center, University of Michigan. We would like to thank Michele Yankson and Angela Burchard for research assistance. Correspondence should be directed to the first author at: University of Michigan Department of Sociology, 500 South State Street, Ann Arbor, MI 48109-1382, E-mail: burgards@umich.edu.

SLEEP DURATION AND MORTALITY RISK: DO SOCIAL FACTORS MODERATE THE RELATIONSHIP?

Abstract

Extant research shows that sleep duration is associated with mortality, but prior studies have not examined comprehensively how the association may vary by sex, race, or socioeconomic status (SES). We use data from the National Health Interview Study, a large, nationally-representative sample with a twelve year period of mortality follow-up, and Cox proportional hazard models of mortality risk to explore how social factors may mediate or moderate the sleep duration –mortality association. Preliminary results show that the relationship between short sleep duration and subsequent mortality is explained more by differences in health status than by social factors. By contrast, long sleepers have higher mortality due to their social and health characteristics, but an unexplained disadvantage in mortality risk still remains even with these controls. Findings also suggest that the sleep duration-mortality relationship is similar across social groups, though educational differences in the association are apparent among men but not women.

SLEEP DURATION AND MORTALITY RISK: DO SOCIAL FACTORS MODERATE THE RELATIONSHIP?

INTRODUCTION

Extant research suggests that sleep duration is associated with mortality in the United States. Higher mortality risk is associated with regular sleep durations of fewer than 7 hours (Breslow and Enstrom 1980; Heslop et al. 2002; Hublin et al. 2007; Kripke et al. 2002; Patel et al. 2004; Tamakoshi and Ohno 2004; Wingard and Berkman 1983) or more than 8 to 9 hours (Breslow and Enstrom 1980; Burazeri, Gofine and Kark 2003; Gale and Martyn 1998; Hublin et al. 2007; Kripke et al. 2002; Lan et al. 2007; Mallon, Broman and Hetta 2002; Patel et al. 2004; Tamakoshi and Ohno 2004; Wingard and Berkman 1983), relative to average durations of 7 to 8 hours per night. However, prior studies have not examined comprehensively how the sleep duration-mortality relationship may vary across socially-relevant subgroups defined by sex, race, and/or socioeconomic status (SES), even though both sleep duration and mortality are stratified by these social characteristics. Social variation in the sleep duration – mortality link could arise due to the unequal social distribution of risk factors, such as tobacco and alcohol use or chronic health conditions, or alternatively because the relationship itself is stronger for some groups than for others. This paper is a first attempt to examine these questions in a large, nationally-representative sample of U.S. residents with a lengthy mortality follow-up and control for a wide array of important social and health characteristics.

Both sleep duration and the mortality risk are strongly socially stratified, and gender is a central dividing line that reflects social role differences and biological differences throughout the life course. Women have different patterns of labor force participation, different responsibilities for caregiving to young and older relatives, and the association between hormonal changes (primarily in estrogen) and sleep over the life course also differentiates them from men. Some studies have shown that women report longer average sleep durations than men through adult life (Burazeri, Gofine and Kark 2003; Gale and Martyn 1998; but see Tamakoshi and Ohno 2004), though women may be more likely than men to transition to short sleep durations as they age past 65 years (Wingard and Berkman 1983). In contrast to the more complex interplay of social and biological factors that underlie these gender differences, patterns of racial/ethnic and SES variation in sleep duration and in mortality are driven mainly by social factors. These include patterns of time use, engagement in productive activity and employment demands, and environmental factors, such as noisy or dangerous neighborhoods (Hale and Do 2007), all of which may inhibit sleep. African Americans are more likely to report both short (Hale and Do 2007; Stamatakis, Kaplan and Roberts 2007) and long sleep durations (Hale and Do 2007; Lauderdale et al. 2006), relative to whites, and non-optimal sleep durations also appear to be more common among other racial/ethnic groups in the United States as compared to whites (Hale and Do 2007; Stamatakis, Kaplan and Roberts 2007). Less-educated people, those of lower social class, and those not in the labor force also report longer average sleep durations than their better-educated, higher-status, employed counterparts (Burazeri, Gofine and Kark 2003; Gale and Martyn 1998; Heslop et al. 2002; Lan et al. 2007).

The social patterning of health and health behavioral risk factors may also help to explain why some social groups show greater risk of both non-optimal sleep duration and mortality. Short sleepers (Foley et al. 2004; Patel et al. 2004; Tamakoshi and Ohno 2004) and long sleepers (Burazeri, Gofine and Kark 2003; Heslop et al. 2002; Lan et al. 2007; Patel et al. 2004; Tamakoshi and Ohno 2004) have worse chronic disease profiles than those who sleep 7 to 8 hours. Poor mental health is also associated with non-optimal sleep durations (Lan et al. 2007; Tamakoshi and Ohno 2004). Smoking is more common among those reporting short sleep durations (Heslop et al. 2002 (men only); Tamakoshi and Ohno 2004

(women only)) or long sleep durations (Tamakoshi and Ohno 2004 (women only)), and alcohol use appears to be greater among those who sleep less (Heslop et al. 2002 (men only)) or more (Heslop et al. 2002; Patel et al. 2004) than the optimal 7 to 8 hours.

Unequally distributed social and health risk factors may help to explain why sleep duration is linked to mortality risk. Alternatively, the strength or even direction of the sleep duration-mortality relationship could vary across social categories, net of the differential distribution of these risk factors. To our knowledge, however, no studies have explicitly examined whether the relationship operates similarly or differently across sex, race/ethnicity and/or SES categories. Some evidence from the literature suggests that social characteristics may moderate the sleep duration – mortality relationship. Despite their greater likelihood to sleep longer than men, women have lower rates of mortality from most causes across the life course than their male counterparts. At the same time, women suffer more than men from the chronic health conditions associated with sleep difficulties (Rieker and Bird 2005). A handful of studies have shown that even among short (Breslow and Enstrom 1980) and long sleepers (Breslow and Enstrom 1980; Burazeri, Gofine and Kark 2003), males have higher mortality risk than their female counterparts. Part of this gendered pattern may be explained by differences in risk factor profiles - men who are short or long sleepers have worse health behavior profiles (e.g., tobacco and alcohol use) relative to their short or long sleeping female counterparts (Heslop et al. 2002) – but part of it may persist net of risk factors. Thus, we may observe greater variation in mortality risk and in the impact of social and health risk factors across categories of sleep duration for men than for women. By contrast, a large body of research shows that African Americans and some other minority racial/ethnic groups, as well as people with lower-SES, have a significantly higher risk of mortality than whites and those of higher SES, paralleling their poorer sleep duration profiles. A few studies have even suggested that inadequate sleep may contribute to the robust association between SES and mortality (Friedman et al. 2007; Van Cauter and Spiegel 1999).

The underlying aim of this study is thus to examine how social stratification by sex, race/ethnicity and SES may pattern the association between sleep duration and mortality. We address several research questions: (1) is the sleep duration-mortality association explained by the differential distribution of sleep duration by sex, race/ethnicity, and SES? (2) Is the sleep duration-mortality association explained by the differential distribution of social and health risk factors by sex, race/ethnicity, and SES? (3) Do sex, race/ethnicity and/or SES moderate the sleep duration-mortality relationship? (4) Do race/ethnicity or SES moderate the risk associated with non-optimal sleep durations more for men than for women? To address these questions, we use data from the National Health Interview Study, a large, nationally-representative sample with a lengthy twelve year period of mortality follow-up, and Cox proportional hazard models of mortality risk. These data are well-suited to the new research questions that we ask, and greatly improve the generalizability of our results, as prior studies of sleep duration and mortality have generally been conducted using non-representative samples that could not address the potential diversity of associations by sex, race/ethnicity and SES.

DATA AND METHODS

Data

The data analyzed in this study are from the 1990 National Health Interview Survey's Health Promotion and Disease Prevention Supplement, and draw from a nationally representative sample of 41,104 non-institutionalized US adults aged 18 years or older who took part in in-person interviews (Massey et al. 1989; National Center for Health Statistics 1993). Individual data from the supplement were linked to prospective mortality data from the National Death Index (NDI), based on 12 respondent characteristics (Social Security number; first and last names; middle initial; race; gender; marital status; day, month,

and year of birth; and state of birth and residence), with follow-up through December 2002 (National Center for Health Statistics 2000). The analytic sample used for this analysis excluded 342 cases (0.83%) that could not be linked to mortality data due to insufficient identifying information for matching with an NDI record. An additional 1,789 respondents (4.39%) were missing on one or more covariates, with nearly half of these respondents missing information on income. Final multivariate models were estimated using 38,973 respondents, of whom 5,969 died by December 2002.

Measures

Sleep Duration

Sleep duration was obtained from individual responses to the following question: On the average, how many hours of sleep do you get in a 24-hour period? We categorized sleep duration so that 0 = seven to eight hours, treated as the optimal duration, 1 = six hours or less, our measure of short sleep, and 2 = nine hours or more, our measure of long sleep.

Key Independent Variables

Sex was coded so that 0 = female and 1 = male, and race/ethnicity was coded so that 0 = non-Hispanic white (the reference), 1 = non-Hispanic black, 2 = Hispanic, and 3 = other race/ethnicity (includes Asians and Native Americans). We categorized educational attainment for parsimony and to reflect important human capital distinctions, where 0 = more than high school (the reference), 1 = less than high school, and 2 = high school graduate.

Other Independent Variables

We adjusted for sociodemographic and health characteristics associated with sleep duration, mortality, or both. These included a measure of age in years, immigrant status (0 = not foreign born (reference), 1 = foreign born), marital status (0 = currently married (reference), 1= previously married, and 2 = never married). We included a continuous measure of family income that was created by taking the mid-point of 27 pre-coded income category choices, ranging from less than $1000 to $50,000 or more (using a median value of $6845 for the open-ended income category of $50000 or more). For the multivariate analysis we divided family income by 1,000, adjusted for family size, and took the natural log, to account for the diminished impact of additional units of income on mortality as income increases. We also adjusted for current employment status (0 = currently employed (reference), 1 = currently unemployed, and 2 = not in the labor force). We expected the lowest mortality risk for foreign born individuals, currently married people, and those who were currently employed.

Because sleep duration and mortality both may be determined by an individual's health behaviors and health status, we adjusted for a variety of health characteristics. We calculated body mass index (BMI) in the typical way (squared height in meters divided by weight in kilograms) and treated it as a continuous measure. BMI may be associated with sleep disturbance because heavier individuals are at higher risk for sleep apnea. We accounted for level of physical activity with a dichotomous measure indicating whether the respondent regularly engages in exercise (0 = exercises less than regularly or not at all, and 1 = exercises regularly). We included a continuous count of the average number of alcoholic drinks per day (possible range: 0 to 12), and current smoking status was coded so that 0 = never smoker (the reference), 1 = current smoker, and 2 = former smoker. We accounted for health status with a count of the number of days spent in bed in the last 12 months (possible range: 0 to 365), likely an indication of serious health problems. We also included a measure of total number of chronic health conditions (possible range: 0 to 14), which range from respiratory disorders such as asthma to heart disease, stroke, and cancer, but also include less serious conditions like skin ulcers and allergies.

Statistical Analysis

We first examined the distribution of respondent characteristics by mortality status and gender. We then generated unadjusted Kaplan Meier survival plots to explore subgroup differences in survival for each category of sleep duration. Finally, we used Cox proportional hazards models to estimate the relative hazard of mortality by sleep duration categories and indicators of social group membership (sex, race/ethnicity, and education), controlling for health behaviors, heath status, and other sociodemographic characteristics. Survival duration was represented by the number of months from the date of interview to the date of death among those who died, and by the months until the end of the follow-up period for survivors. We added the age at interview to the survival duration to account for the aging effect on mortality. Thus, the survival duration increased as the respondent aged from age 18, until the individual died or the follow up period ended.

The multivariate analysis was conducted in two stages. First, we estimated the relative risk of mortality for the full sample, examining the relative hazard rate for categories of sleep duration, first with no controls and then controlling for sets of predictor variables. Second, we examined the interaction between sleep duration categories and social characteristics (sex, race/ethnicity, education) for the full sample and separately for men and women (race/ethnicity and education). Sample weights were used in all descriptive and multivariate analyses to adjust for the complex sample design, and all analyses were conducted using Stata version 10.

PRELIMINARY RESULTS

Descriptive Results

Table 1 presents the weighted sample characteristics for the sample overall and stratified by mortality status and by sex. Figures presented are proportions or means, as appropriate. Overall, two-thirds of respondents reported sleeping the optimal 7 to 8 hours per day in 1990, while nearly one-quarter reported sleeping fewer than seven hours on average, and one in ten reported sleeping nine hours or more. These proportions were essentially the same for those who survived through 2002, while among those who died over follow up, the proportion of long sleepers was considerably higher (0.18), while the proportion sleeping the optimal 7 to 8 hours was lower (0.59). Men and women had similar likelihood of reporting short, optimal, or long sleep in this sample. The lack of a gender difference in these weighted but unadjusted figures appears to be due our choice about how to categorize sleep durations and the lack of control for respondent age.[1]

Other characteristics of the sample reflect expected differences by vital status and by sex. Respondents who died over follow up were considerably older (66.0 years) than those who survived (40.3 years), on average. Mortality was slightly lower among Hispanics, those from “other” racial/ethnic groups, and the foreign born. Those who died were less likely to be married in 1990 and more likely to be formerly married, and they had less education and lower incomes than survivors. Compared to survivors and men, those who died over follow up and women were less likely to be employed in 1990 and more likely to be out of the labor force. With regard to health and health behaviors, we also find important variation by vital status and sex. Compared to those who survived to 2002, respondents who died over follow up consumed fewer drinks but were more likely to be former smokers and less likely to never have smoked, as well as reporting more bed days and a greater numbers of chronic conditions.

[1] In tabulations not shown here that stratified by respondent age, we observed that women were less likely than men to report sleep durations of 6 or fewer hours and more likely to report durations of 7 to 8 or 9 or more hours.

Compared to men, women drank and smoked less but also exercised slightly less, while bed days and presence of chronic conditions were greater for women but they were less likely to die over follow up.

For greater clarification, Figure 1 illustrates the sex difference in mortality by categories of sleep duration, based on Kaplan Meier plots of survival probabilities. Panel A displays the survival estimates for those reporting short sleep, and shows that at all ages, but particularly after early life, women's' survival is consistently higher than men's survival. This general pattern is reflected in Panel B (7 to 8 hours) and Panel C (9+ hours), but we observe that without adjusting for other covariates, the male disadvantage appears greatest among the long sleepers in Panel C. We turn next to multivariate analyses to try to understand how to explain the variation in the sleep-mortality relationship by sex.

Multivariate Results

Table 2 presents hazard ratios from Cox proportional hazard models of mortality risk, with standard errors in parentheses and Log Likelihoods presented at the bottom for each model. Model 1 shows the unadjusted association between short and long sleep categories and mortality risk, while Model 2 adds controls for sex, race/ethnicity, and educational attainment, our key social characteristics, Model 3 additionally adjusts for place of birth, marital status and income, Model 4 adds an indicator of employment status, Model 5 adds health behavior measures, and Model 6 adds our indictors of health status. Results presented in Table 2 show that in all but the final Model 6, short and long sleepers show a consistently greater hazard of mortality than those who average the optimal 7 to 8 hours of sleep.

Results for Model 1 in Table 2 show that relative to those sleeping 7 to 8 hours per night, short sleepers are significantly more likely to die over follow up (HR = 1.06), but that the risk for long sleepers is much greater (HR = 1.47). The addition of social characteristics in Models 2 through 4 reduce the negative association between long sleep duration and mortality by about 8 percent, while the influence of short sleep remains essentially unchanged. Model 5 adds controls for health behaviors, reducing the association between non-optimal sleep durations and mortality slightly. Finally, Model 6 shows that long sleepers maintain a significantly higher hazard of mortality even with all controls (HR = 1.24), while the hazard for short sleepers actually reverses, so that they have a slightly but significantly lower hazard of death than those sleeping 7 to 8 hours. Since Model 6 adds only the health status variables, this suggests that respondents who sleep six or fewer hours per night because of health problems (i.e., causing pain or otherwise obstructing adequate sleep) may account for the higher risk observed for short sleepers overall in simpler models.

The results presented in Table 2 provide preliminary answers to our first two research questions; we find that the relationship between short sleep duration and subsequent mortality is not driven by differences in the social characteristics of short versus optimal sleepers, but probably is explained by differences in their health status. By contrast, the association between long sleep duration and mortality is partially accounted for by the differential distribution of sleep duration across categories of sex, race/ethnicity, and SES, as well as by the different health behavioral and health status profiles of these groups. Nonetheless, even with all controls in Model 6, we continue to observe a greater risk of mortality for those sleeping 9 or more hours per night.

We suspected that we might see greater social variation in the association between sleep duration and mortality among men than among women. We next turn to interaction models to explore the remaining unexplained gap between optimal and long sleepers further, and to see how it may vary by sex. Table 3 shows hazard ratios from Cox proportional hazard models of mortality risk, showing interactions between sleep duration categories and categories of educational attainment, a central measure of SES.

The left panel displays results for the entire sample (Models 1 and 2), while the middle (Models 3 and 4) and right panels (Models 5 and 6) of the table show results for men and women separately. In models not shown, we found no moderating effects of sex or race/ethnicity on the sleep duration-mortality relationship, so we do not present those findings here. Moreover, only after stratifying the sample by sex do we observe the full moderating effect of educational attainment on the association, one that it is concentrated among men. Models 5 and 6 do not even show statistically significant associations between long sleep duration and mortality for women, though the hazard ratios are in the expected direction.

By considering the covariates associated with the main and interactive effects of sleep duration and education presented in Models 3 and 4, we find that compared to those with more than a high school education who sleep the optimal 7 to 8 hours per night (the reference category), the relative risk of mortality is higher for similarly well-educated men who sleep 9 or more hours per night, but not for those who report short sleep. Turning to those with less schooling, we find that when compared to their better-educated counterparts who sleep 7 to 8 hours per night, relative mortality risk is highest for long sleepers, but also higher for those sleeping 7 to 8 hours and slightly higher for short sleepers. Overall, this suggests that there is less variation in mortality risk by education among men reporting long sleep durations than among optimal or short sleepers, while long sleepers overall still show the greatest risk of mortality. This interaction is not explained by income or employment status in 1990, or by health or health behaviors, and will be explored further in our ongoing analyses.

The preliminary results presented in Table 3 thus address our third and fourth research questions, and suggest that there are relatively few moderating effects of social characteristics – the sleep duration-mortality relationship appears to be fairly universal. However, educational differences in the association do appear more clearly among men.

FUTURE DIRECTIONS

Before the PAA meeting, we will test and extend these findings in several ways, and will conduct sensitivity analyses to explore the robustness of these preliminary results. We will add controls for, and stratify our models by a wider array of specific health conditions to better understand the differential confounding by health that may underlie sleep duration categories (i.e., short versus long sleep duration). We will also test continuous specifications of sleep duration and educational attainment, to explore the statistical significance of interactions. Further covariates and interactions will be explored to better understand the remaining excess mortality risk associated with long sleep durations. Finally, we will explore how these associations may vary across the adult life course.

SOURCES

Breslow, Lester , and James E. Enstrom. 1980. "Persistence of Health Habits and Their Relationship to Mortality." *Preventative Medicine* 9:469-483.

Burazeri, G., J. Gofine, and J.D. Kark. 2003. "Over 8 Hours of Sleep-Marker of Increased Mortality in Mediterranean Population: Follow-up Population Study." *Croatian Medical Journal* 44:193-198.

Foley, Daniel, Sonia Ancoli-Israel, Patricia Britz, and James Walsh. 2004. "Sleep disturbances and chronic disease in older adults: Results of the 2003 National Sleep Foundation Sleep in America Survey." *Journal of Psychosomatic Research* 56:497-502.

Friedman, Elliot M., Gayle D. Love, Melissa A. Rosenkranz, Heather L. Urry, Richard J. Davidson, Burton H. Singer, and Carol D. Ryff. 2007. "Socioeconomic Status Predicts Objective and Subjective Sleep Quality in Aging Women." *Psychosomatic Medicine* 69:682-691.

Gale, Catherine, and Christopher Martyn. 1998. "Larks and Owls and Health, Wealth, and Wisdom." *British Medical Journal* 317:1675-1677.

Hale, Lauren, and D. Phuong Do. 2007. "Racial Differences in Self-Reports of Sleep Duration in a Population-Based Study." *Sleep* 30:1096-1103.

Heslop, Pauline, George Davey Smith, Chris Metcalfe, John Macleod, and Carole Hart. 2002. "Sleep Duration and Mortality: the Effect of Short or Long Sleep Duration on Cardiovascular and All-Cause Mortality in Working Men and Women." *Sleep Medicine* 3:305-314.

Hublin, Christer, Markku Partinen, Markku Koskenvuo, and Jakko Kaprio. 2007. "Sleep and Mortality: A Population-Based 22 Year Follow-up Study." *Sleep Journal* 30:1245-1253.

Kripke, Daniel F. , Lawrence Garfinkel, Deborah L. Wingard, Deborah L. Klauber, and Matthew R. Marler. 2002. "Mortality Associated with Sleep Duration and Insomnia." *Archives of General Psychiatry* 59:131-138.

Lan, Tzuo-Yun, Tsuo-Hung Lan, Chi-Pang Wen, Yu-Hsuan Lin, and Yi-Li Chang. 2007. "Nighttime Sleep, Chinese Afternoon Nap, and Mortality in the Elderly." *Sleep Journal* 30:1105-1110.

Lauderdale, Diane S., Kristen L. Knutson, Lijing L. Yan, Paul J. Rathouz, Stephen B. Hulley, Steve Sidney, and Kiang Liu. 2006. "Objectively Measured Sleep Characteristics among Early-Middle-Aged Adults: The CARDIA Study." *Am. J. Epidemiol.* 164:5-16.

Mallon, L. , J.-E. Broman, and J. Hetta. 2002. "Sleep Complaints Predict Coronary Artery Disease Mortality in Males: a 12-year Follow-up Study of a Middle-aged Swedish Population." *Journal of Internal Medicine* 251:207-216.

Massey, J.T., T.F. Morre, V.L. Parsons, and W. Tadros. 1989. "Design and estimation for the National Health Interview Survey, 1985–1994." *Vital Health Stat* 2.

National Center for Health Statistics. 1993. *National Health Interview Survey, 1990: Health Promotion and Disease Prevention Sample Person Supplement.* Hyattsville, MD: National Center for Health Statistics.

—. 2000. *National Health Interview Survey, Multiple Cause of Death Public Use Data File: 1986–1997 Survey Years*. Hyattsville, MD: National Center for Health Statistics.

Patel, Sanjay R., Najib T. Ayas, Mark R. Malhotra, David P. White, Eva S. Schernhammer, Frank E. Speizer, and et al. 2004. "A Prospective Study of Sleep Duration and Mortality Risk in Women." *Sleep* 27:440-444.

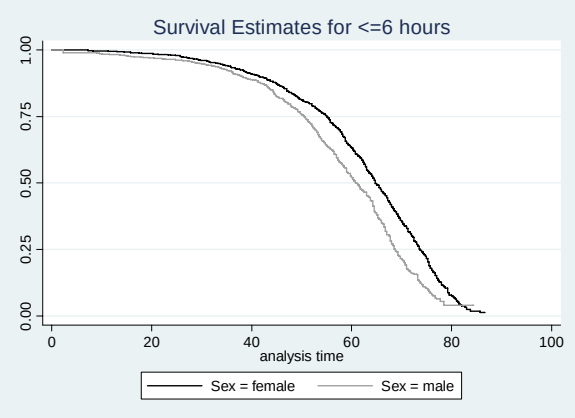
Rieker, Patricia P., and Chloe E. Bird. 2005. "Rethinking Gender Differences in Health: Why We Need to Integrate Social and Biological Perspectives." *Journals of Gerontology B* 60:S40-47.

Stamatakis, Katherine A., George A. Kaplan, and Robert E. Roberts. 2007. "Short Sleep Duration Across Income, Education, and Race/Ethnic Groups: Population Prevalence and Growing Disparities During 34 Years of Follow-Up." *Annals of Epidemiology* 17:948-955.

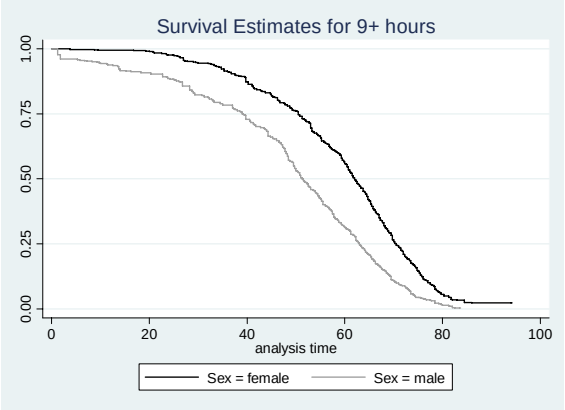
Tamakoshi, Akiko, and Yoshiyuki Ohno. 2004. "Self-Reported Sleep Duration as a Predictor of All-Cause Mortality: Results from the JACC Study, Japan." *Sleep* 27:51-54.

Van Cauter, Eve , and Karine Spiegel. 1999. "Sleep as a Mediator of the Relationship between Socioeconomic Status and Health: A Hypothesis." *Annals of the New York Academy of Sciences* 896:254-261.

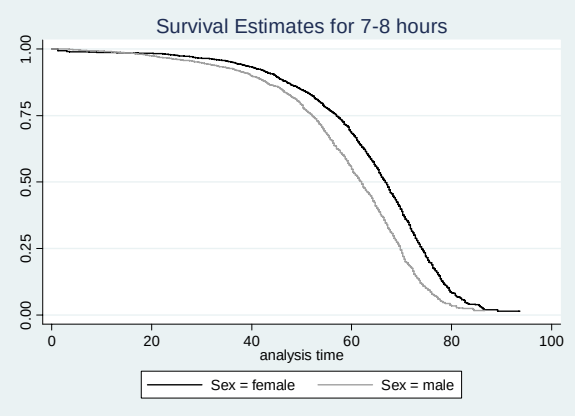
Wingard, Deborah L., and Lisa F. Berkman. 1983. "Mortality Risk Associated with Sleeping Patterns among Adults." *Sleep* 6:102-107.



Panel A: <=6 hours



Panel C: 9+ hours



Panel B: 7-8 hours

Figure 1. Unadjusted Kaplan Meier plots of survival by sleep duration and sex.

Table 1. Weighted Sample Characteristics by Mortality Status and Gender: National Health Interview Survey, 1990-2002

		Mortality Status[a]		Gender	
	Total	Survived	Died	Men	Women
Unweighted total N	38973	33004	5969	16412	22561
Sleep Duration					
6 hours or less	0.24	0.24	0.23	0.25	0.24
7-8 hours	0.66	0.67	0.59	0.65	0.66
9 hours or more	0.10	0.09	0.18	0.10	0.10
Sociodemographic Characteristics					
Age, years, mean	43.7 (17.6)	40.3 (15.3)	66.0 (15.2)	42.9 (17.0)	44.5 (18.1)
Male, proportion	0.48	0.47	0.52	1.00	1.00
Race/Ethnicity, proportion					
Non-Hispanic White	0.78	0.78	0.83	0.79	0.78
Non-Hispanic Black	0.11	0.11	0.11	0.10	0.11
Hispanic	0.08	0.08	0.05	0.07	0.08
Other	0.03	0.04	0.02	0.04	0.03
Foreign born	0.10	0.10	0.07	0.10	0.10
Marital Status, proportion					
Currently married	0.65	0.66	0.59	0.69	0.62
Previously married	0.17	0.14	0.34	0.10	0.22
Never married	0.18	0.20	0.08	0.21	0.16
Socioeconomic Characteristics					
Education, proportion					
< High school	0.13	0.11	0.30	0.12	0.14
High school	0.36	0.36	0.37	0.35	0.37
> High school	0.51	0.54	0.34	0.53	0.49
Family income in 1000s, $, mean	23.7 (14.6)	24.5 (14.5)	18.5 (13.5)	25.1 (14.6)	22.4 (14.4)
Employment Status, proportion					
Currently employed	0.66	0.72	0.27	0.75	0.57
Unemployed	0.03	0.03	0.02	0.03	0.03
Not in the labor force	0.31	0.25	0.71	0.21	0.40
Health Characteristics					
Body Mass Index, mean	25.1 (4.7)	25.0 (4.7)	25.5 (5.0)	25.7 (4.1)	24.5 (5.2)
Average num alcoholic drinks (per day), mean	1.4 (2.0)	1.5 (2.1)	1.0 (1.7)	2.0 (2.4)	1.0 (1.4)
Smoking Status, proportion					
Never smoker	0.50	0.51	0.40	0.41	0.58
Former smoker	0.25	0.23	0.34	0.30	0.19
Current smoker	0.26	0.26	0.26	0.28	0.23
Exercise regularly (1=yes), prop	0.41	0.43	0.28	0.44	0.38
Number of days spent in bed (12 mo), mean	5.7 (26.2)	4.5 (20.3)	13.7 (48.6)	5.1 (25.9)	6.4 (26.5)
Number of chronic conditions (ever), mean	0.9 (1.4)	0.7 (1.2)	1.9 (1.9)	0.8 (1.3)	1.0 (1.4)
Overall mortality (1=died), prop	0.13	0.00	1.00	0.14	0.12
Duration, months, mean	56.1 (16.7)	53.4 (15.3)	73.4 (15.3)	55.1 (16.1)	56.9 (17.3)

[a] Mortality was assessed through the end of 2002

Table 2. Hazard Ratios (HRs) From Cox Proportional Hazard Models of the Risk of Death Among US Adults, National Health Interview Survey with Mortality Follow-Up, 1990-2002

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	HR (SE)	HR (SE)	HR (SE)	HR (SE)	HR (SE)	HR (SE)
Sleep Duration						
6 hours or less	1.06 (0.02) ***	1.06 (0.01) ***	1.05 (0.01) ***	1.06 (0.01) ***	1.04 (0.01) ***	0.99 (0.00) ***
9 hours or more	1.47 (0.10) ***	1.37 (0.09) ***	1.37 (0.10) ***	1.35 (0.10) ***	1.30 (0.08) ***	1.24 (0.09) **
Male	--	1.58 (0.06) ***	1.72 (0.06) ***	1.79 (0.07) ***	1.62 (0.06) ***	1.60 (0.06) ***
Race/Ethnicity[a]						
Non-Hisp. Black	--	1.14 (0.04) ***	1.03 (0.04)	1.04 (0.04)	1.04 (0.04)	1.08 (0.05)
Hispanic	--	0.87 (0.01) ***	0.92 (0.01) ***	0.93 (0.01) ***	0.91 (0.02) ***	0.93 (0.03) *
Other	--	0.67 (0.08) ***	0.74 (0.11) *	0.73 (0.10) *	0.78 (0.09) *	0.83 (0.10)
Foreign born	--	--	0.74 (0.03) ***	0.75 (0.03) ***	0.78 (0.03) ***	0.80 (0.03) ***
Marital Status[a]						
Previously married	--	--	1.12 (0.04) ***	1.14 (0.03) ***	1.10 (0.03) ***	1.05 (0.03)
Never married	--	--	1.23 (0.03) ***	1.24 (0.03) ***	1.27 (0.03) ***	1.27 (0.01) ***
Education[a]						
< High school	--	1.58 (0.06) ***	1.28 (0.04) ***	1.27 (0.03) ***	1.20 (0.05) ***	1.20 (0.05) ***
High school	--	1.30 (0.07) ***	1.17 (0.06) ***	1.17 (0.06) ***	1.12 (0.06) *	1.13 (0.07) *
Family income	--	--	0.76 (0.01) ***	0.80 (0.01) ***	0.84 (0.01) ***	0.88 (0.01) ***
Employment Status[a]						
Unemployed	--	--	--	1.34 (0.16) *	1.26 (0.14) *	1.28 (0.14) *
Not in labor force	--	--	--	1.49 (0.07) ***	1.49 (0.05) ***	1.35 (0.05) ***
BMI	--	--	--	--	1.01 (0.00) **	1.01 (0.00) *
Alcoholic Drinks	--	--	--	--	1.00 (0.01)	1.01 (0.01)
Smoking Status[a]						
Former smoker	--	--	--	--	1.27 (0.04) ***	1.25 (0.04) ***
Current smoker	--	--	--	--	2.09 (0.03) ***	2.09 (0.02) ***
Exercise regularly	--	--	--	--	0.77 (0.01) ***	0.80 (0.01) ***
Bed days	--	--	--	--	--	1.00 (0.00) ***
Chronic conditions	--	--	--	--	--	1.10 (0.00) ***
N	40556	40506	39709	39709	39160	38973
Log Likelihood	-22240	-21990	-21184	-21134	-20581	-20276

Note: ***p<.001, **p<.01, *p<.05.

a. Omitted categories are: Race/ethnicity = non-Hispanic white, marital status = married, Education = > high school, employment status = employed, smoking status = never smoker

Table 3. Hazard Ratios (HRs) From Cox Proportional Hazard Models of the Risk of Death Among US Adults, Overall and Stratified by Sex, National Health Interview Survey with Mortality Follow-Up, 1990-2002

	Panel A: Full Sample		Panel B: Men		Panel C: Women	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Sleep Duration	HR (SE)	HR (SE)	HR (SE)	HR (SE)	HR (SE)	HR (SE)
6 hours or less	1.05 (0.02) ***	1.00 (0.02)	1.05 (0.05)	1.01 (0.05)	1.06 (0.10)	1.01 (0.10)
9 hours or more	1.46 (0.19) **	1.35 (0.19) *	1.52 (0.13) ***	1.44 (0.12) ***	1.30 (0.22)	1.16 (0.22)
Male	1.79 (0.07) ***	1.60 (0.06) ***	--	--	--	--
Race/Ethnicity[a]						
Non-Hisp. Black	1.04 (0.04)	1.08 (0.05)	1.03 (0.08)	1.07 (0.07)	1.01 (0.04)	1.07 (0.06)
Hispanic	0.93 (0.01) ***	0.93 (0.03) *	0.90 (0.09)	0.93 (0.05)	0.97 (0.09)	0.99 (0.10)
Other	0.73 (0.10) *	0.83 (0.09)	0.55 (0.17) *	0.63 (0.19)	1.01 (0.14)	1.16 (0.16)
Foreign born	0.74 (0.02) ***	0.79 (0.03) ***	0.68 (0.04) ***	0.71 (0.04) ***	0.79 (0.04) ***	0.89 (0.03) ***
Marital Status[a]						
Previously married	1.14 (0.03) ***	1.05 (0.03)	1.15 (0.06) **	1.06 (0.06)	1.13 (0.02) ***	1.02 (0.02)
Never married	1.24 (0.03) ***	1.27 (0.01) ***	1.25 (0.07) ***	1.33 (0.10) ***	1.18 (0.11)	1.14 (0.09)
Education[a]						
< High school	1.30 (0.04) ***	1.21 (0.05) ***	1.27 (0.12) **	1.21 (0.10) *	1.31 (0.05) ***	1.20 (0.04) ***
High school	1.19 (0.05) ***	1.17 (0.06) **	1.25 (0.11) *	1.25 (0.10) **	1.11 (0.05) *	1.08 (0.06)
Family income	0.80 (0.01) ***	0.88 (0.01) ***	0.75 (0.03) ***	0.84 (0.02) ***	0.85 (0.04) ***	0.90 (0.04) *
Employment Status[a]						
Unemployed	1.34 (0.16) *	1.28 (0.14) *	1.50 (0.23) **	1.44 (0.23) *	0.87 (0.27)	0.85 (0.21)
Not in labor force	1.49 (0.07) ***	1.35 (0.05) ***	1.56 (0.08) ***	1.40 (0.08) ***	1.40 (0.06) ***	1.29 (0.04) ***
*Sleep*Education Interactions*						
Less than 6 hours						
Less than high school	1.04 (0.03)	1.03 (0.04)	1.00 (0.09)	0.98 (0.06)	1.04 (0.10)	1.03 (0.09)
High school	0.98 (0.02)	0.94 (0.02) *	0.91 (0.03) **	0.85 (0.04) ***	1.02 (0.12)	1.00 (0.11)
More than 9 hours						
Less than high school	0.86 (0.10)	0.90 (0.12)	0.85 (0.05) **	0.87 (0.07)	0.85 (0.18)	0.94 (0.22)
High school	0.94 (0.07)	0.88 (0.07)	0.93 (0.02) ***	0.84 (0.03) ***	1.06 (0.15)	1.07 (0.16)
BMI	--	1.01 (0.00) *	--	1.01 (0.01)	--	1.01 (0.00)
Alcoholic Drinks	--	1.01 (0.01)	--	1.00 (0.01)	--	1.02 (0.03)
Smoking Status						
Former smoker	--	1.25 (0.04) ***	--	1.22 (0.10) *	--	1.31 (0.04) ***
Current smoker	--	2.09 (0.03) ***	--	1.95 (0.09) ***	--	2.33 (0.11) ***
Exercise regularly	--	0.80 (0.01) ***	--	0.83 (0.04) ***	--	0.77 (0.04) ***
Bed days	--	1.00 (0.00) ***	--	1.00 (0.00) ***	--	1.00 (0.00) ***
Chronic conditions	--	1.10 (0.00) ***	--	1.12 (0.01) ***	--	1.08 (0.01) ***
N	39709	38973	16649	16412	23060	22561
Log Likelihood	-21132	-20275	-7543	-7290	-9935	-9395

Note: ***p<.001, **p<.01, *p<.05. a. Omitted categories same as in Table 2.