Policy suggestions to reduce economic consequences of sleep curtailment in the United States

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Introduction

Despite a significant increase in the number of leisure hours per day in the United States between 1965 and 2003 (Aguiar and Hurst 2007), the number of Americans who are short sleepers has increased significantly (Knutson et. al. 2010). The National Sleep Foundation estimated that adults (aged 17 and above) need 7-9 hours of sleep per day (*How Much Sleep Do We Really Need?* National Sleep Foundation 2013), yet 44% of American adult workers report sleeping less than 7 hours and 16% report sleeping less than 6 hours on a typical weeknight (*Sleep in America: 2008 Poll*). According to the Center for Disease Control (CDC), over 30% of Americans have reported unintentionally falling asleep during the day at least once during the past month, regardless of age (*Insufficient Sleep is a Public Health Epidemic,* 2013). These studies, and other similar studies in other westernized countries, have shown that the trend to curtail sleep hours is widespread. Sleeping is essential for our survival, and persistent insufficient sleep, known as sleep debt, has been shown to greatly impede individual mental and physical health (Colten & Altevogt 2006). Poor sleep habits lead to adverse metabolic and cardiovascular function causing massive medical costs. Multiple experimental and epidemiologic studies have provided evidence that insufficient sleep contributes to the current epidemics of obesity and diabetes. Conversely, these epidemics have increased the prevalence of pathological sleep disorders, particularly sleep apnea. It is estimated that 50 to 70 millions Americans suffer from a sleep disorder (Colten & Altevogt 2006).

In addition to contributing to poor health, inadequate sleep has been shown to have serious negative consequences for society. Lowered cognitive function due to poor sleep results in increased errors on the job and increased vehicular accidents. Inadequate sleep is not only detrimental to the individual, but also to society; insufficient sleep and poor sleep have been linked to increased risk of vehicular accidents, medical errors, industrial and engineering disasters, and a general increase in performance errors due to the reduced alertness, impaired cognitive function, and delayed response times (Mitler et al. 1988, Institute of Medicine 2006). Poor sleep is thus not only a concern for individual health, productivity and well-being, but for the health, productivity and well-being of society.

This paper seeks to identify the reasons why habitual short sleep (reporting less than six hours of sleep) has increased throughout the United States and to evaluate the social and

economic consequences. Policy changes must be made to reduce the negative consequences generated by increasing trends towards insufficient sleep. Policy incentives should consider the socioeconomic influences that significantly impact our sleep choices. In order to increase sleep time in the U.S., and consequently improve public health, public policies must be enacted. This paper reviews the issues of sleep and sleep disorders and suggests policy measures to counteract and lower the costs of a restless nation. This paper omits a discussion of insomnia and narcolepsies as these sleep disorders are not as prevalent in the population.

Literature Review

Trends of Short Sleep

The Center for Disease Control and Prevention have compiled data from self-reports of insufficient sleep in the United States that show that 7.9%-19.3% of adults report having 30 consecutive days of insufficient rest or sleep (Map of Sleep Insufficiency, 2000). Moreover, according to the CDC, 23.2% of adults reported difficulties concentrating due to insufficient sleep (*Insufficient Sleep is a Public Health Epidemic* 2013). In addition to numerous recent reports of insufficient sleep, analysis of time-use in the United States shows that the prevalence of short sleepers (defined as those reporting less than six hours of sleep) among full-time workers has increased significantly between 1975 and 2006 (Knutson et. al. 2010). In addition to self-reported evidence of inadequate sleep, analysis of secular trends documents the curtailment of sleep in the United State in the last fifty years (McAllister et. al. 2009). This research shows that the average sleep time for adults in the United States has fallen from about 8.5 hours per night in 1960 to 6.8 hours per night in 2004. Indeed, the 2008 poll from the National Sleep Foundation found that 29% of participants reported sleeping less than six hours on weekdays, 41 % indicated sleeping 6-7 hours on weekdays, and only 21 % reported sleeping between 7 and 8 hours on weekdays (National Sleep Foundation 2008). Despite a significant increase in the number of leisure hours per day in the United States between 1965 and 2003 (Aguiar & Hurst 2007), Americans sleep less today than they did in the past (McAllister et. al. 2009). In 1995, Bonnet and Arand (1995) estimated that more than 36% of the population is affected by sleep loss. Altogether, these studies confirm both the perception of insufficient sleep and the persistent existence of the trend for an increased prevalence of short sleep in the United States.

Consequences of Inadequate Sleep: Obesity and Type 2 Diabetes

Concurrently with the accumulation of this data on the increased prevalence of sleep deprivation has been the collection of studies documenting a striking rise in obesity throughout the United States. Referring to Figure 6 (McAllister et. al. 2009) we see that as the number of hours of sleep per day has fallen in the past 50 years, the percentage of obese persons in the United States has increased significantly, from about 13% in 1960 to 32.9% in 2002. The CDC has compiled a very large body of data that clearly shows an enormous rise in obesity rates throughout the country between 1985 and 2010 (CDC: Adult Obesity Facts, 2010). The proportion of adults with obesity increased in every state between 1985 and 2010. While most states in 1985 had an obesity rate of less than 14%, most states in 2010 exhibited obesity rates between 20-35% (CDC: The History of State Obesity Prevalence 2010).

This drastic increase in obesity is especially alarming in light of the fact that obesity is a major risk factor and predictor of several of the most costly and prevalent diseases afflicting Americans today (CDC: Adult Obesity Facts, 2013). Obesity has been shown to increase the risk of high blood pressure, heart disease, type 2 diabetes, and chronic kidney disease, all of which are major contributors to morbidity and health care costs in the United States (Colten & Altevogt 2006). In 1999, Colditz estimated the direct costs for obesity in 1995 totaled 70 billion dollars. In a more recent analysis of national spending on obesity, these costs have nearly doubled. Finkelstein et al. (2009) estimated that the annual medical costs attributable to obesity have risen to almost 10 percent of all annual medical expenditures, with costs totaling $147 billion in 2008. Additionally, the CDC estimates that medical costs for obese individuals are $1,429 higher than medical costs for normal weight individuals (CDC: Adult Obesity Facts 2010). As previously mentioned, the epidemic of obesity is logically followed by an epidemic of type 2 diabetes: indeed, obesity presents itself as the most important risk factor in determining a patient's chance of becoming diabetic (CDC: Prevent Diabetes 2012). Diabetes is a major, chronic disease that is itself often associated with severe complications, including chronic kidney disease, kidney failure, cardiovascular disease, amputation and blindness (CDC: 2011 National Diabetes Fact Sheet). Concurrent with the increased prevalence of obesity, the number of Americans with diabetes has increased from 1.6 million in 1958 to 21.1 million in 2010; furthermore the CDC released figures in January 2011 showing that the number of American adults with pre-diabetes, a condition associated with a two-fold higher

risk of developing full-on diabetes, had increased from 57 million in 2008 to 79 million in 2010 (CDC: Long-Term Trends in Diagnosed Diabetes; CDC: 2011 National Diabetes Fact Sheet CDC) .

Capuccio et al. (2010) performed a meta-analysis of prospective epidemiologic studies where sleep duration or quality was assessed at baseline and the number of cases of incident diabetes were recorded during the follow up period. This meta-analysis found that the combined relative risk of developing diabetes is between 1.5 and 2.0 for individuals with short or poor sleep. The CDC estimated that direct medical costs attributable to diabetes in 2007 amounted to $116 billion dollars, and indirect costs of disability pay, work loss, and premature mortality attributable to diabetes were $58 billion (CDC: 2011 National Diabetes Fact Sheet).

While the earlier data only showed strong correlations and not definite causation between poor sleep and metabolic conditions, the last two decades have yielded a large number of studies suggesting that poor sleep quantity and quality is a significant contributor to the two major metabolic diseases afflicting Americans, obesity and diabetes. Perhaps most alarming is the fact that these diseases are major contributors to the top causes of death throughout the United States (CDC *Leading Causes of Death,* 2010). Conversely, while studies in the United States have shown that poor sleep quantity or quality are significant contributors to major health issues, studies in countries with better sleep hygiene have shown significantly lower rates of the aforementioned diseases (National Sleep Foundation 2013 International Bedroom Poll). In one of the most important experimental studies linking poor sleep with obesity, Spiegel et. al. (2004) demonstrated that insufficient or poor quality sleep was directly linked to pathological changes in hormone levels governing satiety and hunger. In this landmark study, Spiegel et. al. (2004) showed that restricting sleep to 4 hours per night for six days causes a decrease in the hormone leptin, the hormone principally responsible for governing the sensation of satiety. When an individual has eaten, leptin is released and the individual's sensation of hunger decreases. Spiegel et. al. showed that this response is sharply diminished if the individual's sleep is curtailed to 4-hours- under these conditions, the individual has a decreased sense of satiety following a meal and is therefore more likely to continue eating, despite the absence of any sort of caloric insufficiency. In addition to this decrease in satiety, this same sleep restriction study by Spiegel et. al. has shown that the hormone ghrelin, which is responsible for the sensation of hunger, is increased. In physiologically normal individuals, the

release of ghrelin acts as a signal to induce hunger and initiate a meal. However, Spiegel et. al. (2004) showed that ghrelin secretion could be "artificially" elevated simply by curtailing sleep. Consequently, an individual with curtailed sleep has increased hunger sensations despite not having decreased their caloric consumption, and they are likely to gain weight (Taheri et. al. 2004). This study showed a direct, causal, hormonal link between obesity and sleep deprivation, an extremely important step in demonstrating the causality and not just the correlation between curtailed sleep and obesity. Furthermore, this link is even more apparent in employed Americans: individuals who sleep less than 6 hours on workdays are significantly more likely to be obese than those who sleep 8 hours or more (2008 Sleep In America Poll, 10). In conclusion, poor sleep leads to hormonal changes that induce eating and weight gain. and increased risks of sleep disorders, which worsen the quality of sleep.

Obstructive sleep Apnea (OSA) is overwhelmingly found in overweight and obese patients and is due to a complete (apnea) or partial (hypopnea) physical obstruction of the airway, thereby preventing the normal breathing pattern and causing micro-arousals to re-initiate breathing (Peppard et. al. 2012). This disorder is characterized by the apnea/hypopnea index (AHI) which quantifies the number of events per hour. The microarousals cause a fragmentation of the normal sleep architecture, which is detrimental to a person's physiological function (Martin et. al. 1996). It is important to note that patients suffering from OSA do not realize that they are experiencing these microarousals: however, studies done by Peppard et. al. (2012) have shown that patients with severe cases of OSA can have up to one hundred microarousals per hour, a phenomenon which seriously disrupts their sleep. Due to the epidemic of obesity, the prevalence of sleep-disordered breathing has increased by 14% in some subgroups, and 55% in others in the past twenty years (Peppard et. al. 2012).

Another study by Spiegel et. al. (2005) demonstrated that sleep deprivation increased insulin resistance, one of the most significant contributors to diabetes. In this study, the sleep of young healthy participants was curtailed to 4 hours per night for 6 nights. By the 6th night, participants with poor sleep had much higher insulin levels than at baseline (Spiegel et. al. 2005). These higher insulin levels represented an increased resistance to insulin itself, essentially demonstrating that the patients had entered a pre-diabetic stage (Pamidi & Tasali 2012). Further studies on the link between poor sleep quantity and quality and insulin resistance have strengthened the probability of this causal relationship (Yaggi et. al. 2006).

Additional studies of the impact of poor sleep quantity and quality on metabolic function have established a strong correlation between high blood pressure and sleep curtailment (Knutson et. al. 2009). High blood pressure is an extremely prevalent condition in the United States, affecting 1 in 3 Americans – about 67 million people (CDC *High Blood Pressure Facts* 2013). Furthermore, high blood pressure is itself linked to other highly prevalent diseases such as heart disease and, more recently, kidney disease. Chronic kidney disease (CKD) affects about 10% of U.S. adults (CDC *2014 National Chronic Kidney Disease Fact Sheet*) and is an extremely costly disease to treat. Recent studies have demonstrated a high prevalence of poor sleep quantity and quality in patients with CKD, as well as abnormal blood pressure regulation in otherwise healthy individuals with curtailed sleep (Iliescu et. al. 2004). This relationship between poor sleep quantity and quality and high blood pressure and kidney disease further suggests that sleep disturbances are negatively contributing to the risk of two serious conditions that have reached epidemic levels in the United States (Coresh et. al. 2007).

Diabetes, heart disease, and chronic kidney disease are among the most prevalent causes of death in the United States (CDC *Leading Causes of Death* 2010). These diseases have been shown to be associated with curtailed sleep (Institute of Medicine, 2006). Furthermore, the long-term nature of these diseases, which often last several decades, implies that they are exceedingly costly to treat, necessitating continual treatment over a lifetime. Expenditures for CKD in 2010 accounted for 17% of total Medicare dollars, a dramatic increase from only 5.8% in 2000 (2012 USRDS Annual Data Report). Obesity, diabetes, heart disease, and chronic kidney disease represent an enormous, percentage of the cost of health care in the United States, a particularly salient fact in light of the recent debate over policy changes regarding the cost of healthcare in America.

Inadequate sleep and impaired cognitive function

In addition to the aforementioned metabolic consequences of sleep deprivation, there are also numerous studies that have shown measurable decreases in cognitive function in individuals with curtailed sleep. In these studies, recurrent days of short sleep leads to a cumulative sleep debt resulting in significant cognitive impairment (Colten & Altevogt 2006). When total sleep time is reduced by 1-1.5 hours for one night, young healthy adults experience

a 32% decrease in objective alertness, as measured by the Multiple Sleep Latency Test (Bonnet & Arand 1995). The MSLT is designed to measure daytime sleepiness by presenting a test subject with five opportunities to nap, with each nap separated by 2-hour breaks. The speed at which the subjects falls asleep (if at all) during these naps is used to determine the degree to which the subject is sleep deprived: since the naps are at times of the day that the subject normally does not sleep, the drive to fall asleep is attributed to a sleep debt that the body is trying to recover from. As summarized below, the social and economic effects of poor individual sleep on cognitive function are most apparent in transportation accidents, medical errors, and academic performance indicators.

Transportation Accidents

The daytime sleepiness measured by the MSLT can be extremely dangerous and costly to society. In the U.S. population, it is believed that nearly 20% of all serious car crashes are related to driver fatigue, independent of alcohol effects (Colten & Altevogt 2006). Furthermore, a report from the U.S. Department of Transportation (2013) suggests that drowsy driving due to inadequate sleep leads to 1,550 fatalities and 40,000 nonfatal injuries per year in the United States alone (*Drowsy driving and automobile crashes* 2013). It has been shown that over the course of one year, 1% of drivers have experienced a car crash or a near miss due to drowsiness (National Sleep Foundation 2009). Sleepiness leads to crashes because it causes slower reaction times, reduced vigilance, and deficits in information processing which are all critical to safe driving (Dinges 1995).

Lowered Job Productivity

A reduction of sleep time by just one hour can significantly increase the likelihood of human error during the nighttime and afternoon hours, i.e. from midnight to 6am and from 2pm to 6pm (Mitler et al. 1988). For night shift workers and medical professionals, inadequate sleep translates to difficulty concentrating on and off the job, and even disastrous incidents due to lowered alertness, carelessness, or delayed reactions (Mitler et. al. 1988). Poor sleep leads to lowered job productivity and translates to billions of dollars lost due to reduced manufacturing productivity, increased vehicle and industrial accidents, and increased personal injury and fatalities. In 1993, it was estimated that these costs totaled $65.2 billion (Colten & Altevogt

2006). Since the frequency of occurrence of catastrophic events is magnified by insufficient sleep, it is in the best interest of employers, policymakers, and individuals themselves to promote healthy sleep habits to ensure maximum cognitive function inside the workplace.

Medical Errors

Because of the critical nature of the medical profession, it is important to discuss the role of long work hours and short sleeping and the increased risk of error. We do not know the direct costs of this due to the complexity of determining sleepiness to medical errors. However, long work hours, extended shifts, and shift work have all been found to contribute to the estimated 98,000 annual deaths due to medical errors in the U.S. (Colten & Altevogt 2006; Mitler et. al. 1988). Medical residents and nurses typically have long shifts and substitute sleep time for work time.

Adolescent Phase Delay and Cognitive Development

Cognitive impairment due to curtailed sleep is not only documented in transportation and medical errors, but in adolescent school performance. It is widely reported that adolescents go to bed at later times as they get older. Indeed, average sleep time decreases by 40-50 minutes from ages 13 to 19 (Colten & Altevogt 2006). Sleep and wake time shift as a result of biological factors as well as environmental and social factors (Crowley et. al. 2007). Yet high school start times are often the same or even earlier than middle school start times (National Sleep Foundation 2006). Therefore, as adolescents' biological development causes them to go to sleep later in the night, school policies make them wake up earlier in the morning, severely curtailing sleep time. The National Sleep Foundation found that 45% of adolescents get insufficient sleep (less than 8 hours) and are more likely to be fatigued, have irritable and depressed moods, fall asleep in school, have poorer grades and are more likely to drink caffeinated drinks (NSF: 2006 Sleep In America Poll).

"Optimal" Sleep

The main argument levied against the significance of sleep for health and well-being is that different individuals require different amounts of sleep, and that it is therefore meaningless to prescribe a given amount of sleep as "healthy." However, a study by Klerman and Dijk

(2005) has shown that habitually shorter sleep time is strongly associated with an increased sleep debt, as evidenced by reduced sleep latencies, suggesting that sleep debt is prominent throughout populations, regardless of individual "need for sleep". The National Sleep Foundation estimates that individuals need a minimum of 7 hours per day (*How Much Sleep Do We Really Need?* National Sleep Foundation 2013).

Theory: Influences on individual sleep choices

By combining studies done on the effect of poor sleep quantity and quality on metabolic function with studies on the prevalence and severity of obstructive sleep apnea (a sleep disorder characterized by repeated total or partial obstruction of the upper airways), one clearly comes to the conclusion that a vicious cycle of disease and adverse consequence has been established in American society: poor sleep has, as a consequence, the effect of increasing the likelihood of obesity; furthermore, obesity itself has the consequence of increasing the likelihood of poor sleep quality and quantity, thereby closing the self-perpetuating cycle in question. In order to address and lessen the issues of poor sleep and their economic costs, it is beneficial to speculate about what factors influence the individual choice to either spend time sleeping or stay awake.

We review the current theories of socioeconomic factors and sleep duration in the light of new data. Sleep quantity and quality are strongly associated with race, sex, and socioeconomic status (Lauderdale et. al. 2006). Biddle and Hamermesh (1990) suggest that as income increases, sleep time decreases as a result of the higher opportunity cost of time. In other words, this work suggests that as individuals make more money, they are more willing to substitute work time for sleep time. We have been able to analyze recent unpublished data (Knutson & Van Cauter, personal communication, 2014) to examine this theory.

New evidence concerning socioeconomic status and sleep duration

As will be shown below, analysis of data from an unpublished cross-cultural survey study between 2001 and 2004 contradicts this theory that sleep time decreases when wage increases (Knutson & Van Cauter unpublished). This survey was originally intended to study cross-cultural variation in sleep characteristics and the association between sleep duration and

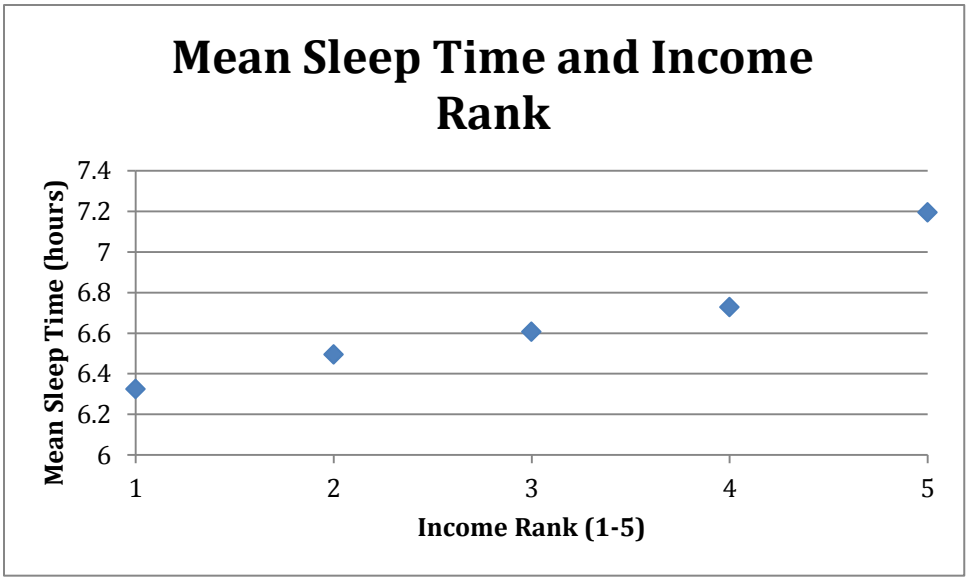
body mass index. Self-administered questionnaires were collected from adults in Brussels, Belgium; Bologna, Italy; and Chicago, Il. This survey collected general information concerning respondents' general health, sleep patterns, education status, employment status, and perceived socioeconomic standing.

A total of 621 U.S. subjects responded to the questionnaire. Respondents were asked how they rank their income level on a scale from 1 (low) to 5 (high) and how they rank their overall social standing from 1-5. A multiple regression analysis was run on the U.S sample with weekly sleep duration as the dependent variable and social rank and age as predictors.

Results showed that those with a higher perceived social rank actually sleep longer than those who perceive that their social rank is low (Knutson and Van Cauter 2014). Additionally, the data suggests that individuals with a higher income sleep more than their lower income counterparts (see figure 1). As income and perceived social rank increases, so does sleep duration. These findings directly contradict Biddle and Hamermeshs' theory (1990) that as income increases, the opportunity cost of sleep increases and thus sleep is lessened. Figure 1 clearly shows that as income increases, sleep increases.

As income increases, the ability to negotiate time for sleep rises. Lower income means spending more hours on the job to make necessary wages, and thus sleep time *must* be substituted for wage time. Higher income individuals feel less economic pressures and do not have to resort to long workdays and short sleeping habits. Further, their occupation may require higher levels of cognitive functioning and they may have recognized the need for sleep to avoid errors and remain productive. Perhaps Biddle and Hamermesh's theory is outdated, or it may be subject to some methodological limitation. It may be that at lower income levels, wage rate increases do lead to a decrease in sleep time. However, our analysis of the data shared by Knutson and Van Cauter shows that sleep time actually increases as income increases. Higher income individuals make more money during each hour of wakefulness and do not have to sacrifice sleep time for time awake. Perhaps higher income individuals are also more aware of the consequences of poor sleep, such as being less productive, less responsive, and more prone to errors on the job. Altogether, it is evident that economic factors influence the individual consumption of sleep. The U.S has more short sleepers because of economic pressures on the individual; poor people are, as a result of low income, more likely to suffer from short sleep and its metabolic consequences and to develop sleep disorders.

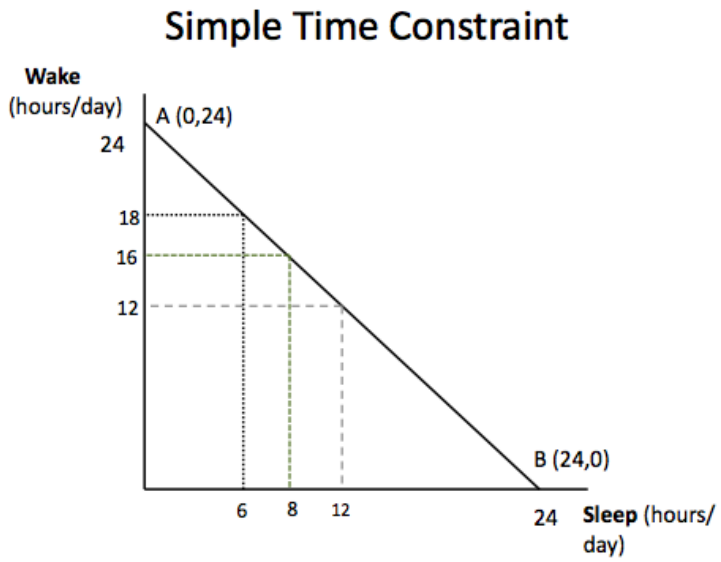
Figure 1:



The consumer choice of the allocation of time between sleep and wake

Sleep is not an easy subject to analyze with an economic lens since sleep is not a good or a service. Sleep is not paid for in the traditional sense; money can be exchanged for goods or services whereas time is exchanged for the expenditure of sleep. In order to understand why individuals consistently choose to "consume" inadequate amounts of sleep, as suggested by the literature, individuals' utility generated by time spent sleeping and time spent awake must be understood. Here, utility is the value or usefulness of time spent. For simplicity, we will categorize time allocation into two exclusive groupings: wake time and sleep time. Wake time consists of all time exclusively spent engaging in market work, non-market work, and leisure. Sleep time refers to time allocated exclusively to sleeping. Restricted by the number of hours in the day, consumers have to choose how to allocate their time between sleep and wake. In the simplest model, time spent sleeping and time spent awake are like two separate goods subject to the budget constraint of time. Individuals chose between certain "bundles" with various proportions of sleep and wake time in an attempt to maximize their utility. Thus the budget constraint is not income, but time. Figure 2 models the various bundles of sleep and wake times subject to the simple time constraint. Here, one hour of sleep is equal to one hour awake, and vise versa.

Figure 2:



Social, cultural, and economic restrictions on time

However, the number of hours in a day is not the only constraint that individuals must face when choosing how much of their time to allocate to sleep or wake. As the data from Knutson and Van Cauter's cross-cultural survey shows, socioeconomic factors influence the consumption of sleep. Low-income individuals sleep less than higher income individuals. Policy initiatives must address the disparities in sleep duration generated by this income gap. Individual choice of sleep time is restricted by certain social, cultural, and economic factors. In addition to these socio-economic influences, individuals consume a certain amount of sleep depending on a variety of factors. Hours spent engaging in work, travel, and leisurely activities are reciprocally related to hours of sleep among Americans (Basner et al. 2007).

Weekend vs. Weekday Allocations of Time

For example, average sleep is greater on weekends than weekdays (2008 Sleep in American Poll), suggesting that the indifference curve for the same individual varies from weekends to weekdays. On weekends, individuals get more utility from sleeping than they do from being awake—since most people do not work on week-ends, the opportunity cost of sleeping is lower than it is for weekdays. However, on weekdays the opportunity cost of sleep (time spent awake and generating income or for non-market production) is greater. Furthermore, as the number of hours spent in market work increase, sleep time decreases (2008

Sleep in America Poll). Working adults, children and adolescents have constraints that influence their choices of time allocation on weekdays versus weekends.

Non-Market Work

Additionally, non-market use of time is subjected to social factors. Taking care of children and family, household cleaning, and food preparation are examples of non-market factors that influence the allocation of time. Biddle and Hamermesh (1990) showed that women sleep less as a result of spending greater proportions of their time than men in non-market work. Furthermore, the presence of children in the household significantly decreases sleep time (Biddle and Hamermesh 1990).

Adolescents and School Start Times

Even though adolescents go through a biologically determined sleep phase delay (Crowley et. al. 2007), primary schools and secondary schools almost always start at the same morning hour, irrespective of biological clock status. Shockingly, many school districts actually have earlier High School start times than middle schools (NSF: 2006 Sleep In America Poll).

Work Schedules

Work and school schedules influence the number of hours we spend awake, and thus the number of hours we spend sleeping. On average, employed people sleep about one hour less per workday than unemployed people (Biddle and Hamermish 1990). A study involving Americans who work at least 30 hours per week found that 54% of respondents work 40-49 hours/week, 17% work between 50 and 59 hours/week, and 13% work more than 60 hours/week (2008 Sleep in American Poll). Additionally, this study found that respondents who worked between 30-39 hours per week spent more time in bed on workdays than those who work more than 40 hours. Interestingly, people tend to go to sleep later on non-work days than workdays and also wake up later in the morning (2008 Sleep In America Poll).

Suggestions for Policy Initiatives to Address America's Inadequate Sleep

The quantity of sleep achieved day by day is too low, and this shortage of sleep generates a multitude of negative consequences for society as well as for the individual. These negative consequences range from automobile and transportation crashes, to medical errors, to lowered job productivity, to increased prevalence of chronic diseases for which inadequate sleep is a risk factor, to increased demands for medical care. The average quantity of sleep consumed by Americans in 2004 was 6.8 hours/day (McAllister et. al. 2009). This quantity of sleep is too low relative to the recommended 8-9 hours of sleep (National Sleep Foundation, *How much Sleep do we really need?* 2013).

In order to directly influence the demand for sleep, public policy must be dealt with. Public policy already influences the decisions we make about sleep. For example, early school start times restrict children's morning sleep schedules. Existing policies influence the number of hours in our work days, overtime hours, and how many hours a transportation employee may be on the job (Fair Labor Standards Act).

The issue of poor sleep throughout the United States must be addressed in order to lower the negative externalities generated by the sleep deficit. Transportation incidents, workplace catastrophes, and health risks may all be reduced by a more sleep-cognizant society. Policy initiatives geared towards reaching the full potential of sleep and healthier sleep habits could greatly reduce the number of Americans affected by sleep debt and consequently lower the negative consequences.

Delay High School Start Times

Recently, policymakers in some states have begun to shift school start times towards later times for high school students. A longitudinal study of the Minneapolis School District found that delaying school start times from 7:15 am to 8:40 am resulted in significant improvements in sleep time, attendance, and mood (Wahlstrom et. al. 2001). Delaying school start times by only 30 minutes was shown to decrease the number of students with sleep times under 7 hours by 79.4% (Owens et. al. 2010). Additionally, students reported more sleep satisfaction and improved motivation and a decrease in daytime sleepiness, fatigue, and depressive moods. School districts nationwide should implement similar policies to delay their

school start times, in order `for their students to get healthier sleep. Specifically, High School start times should be delayed in the light of overwhelming literature documenting a biological phase delay in sleep/wake time in adolescents (Crowley et. al. 2007).

Decrease undiagnosed and untreated sleep disorders

Policy must address the issue of untreated sleep disorders, particularly sleep apnea in the U.S. population. Simply increasing the quantity of sleep is not enough to ensure a healthy sleep for these individuals. More sleep does not necessarily increase their wakefulness nor their well-being. In other words, additional sleep may yield these individuals no more utility because of the inadequate quality of interrupted sleep. Therefore effective policies that specifically target and treat sleep disorders are required.

Young et al. (1997) estimated that 93% of women and 82% of men with moderate to severe sleep apnea syndrome (SAS) have not been clinically diagnosed. In order to lower the number of undiagnosed and untreated sleep disorders we need policy initiatives to increase resources for sleep health care. More physicians trained in sleep medicine could increase diagnosis, treatment, and reduce the negative consequences of poor sleep throughout the U.S. population. A better quality of sleep needs to become more available: most Americans simply do not have adequate health care resources to prevent, diagnose, or manage sleep disorders (Colten & Altevogt 2006).

Today, obstructive sleep apnea is treated with a Continuous Positive Air Pressure (CPAP) machine, a rather rudimentary device that is strapped around the patient's mouth and nose to ensure proper breathing throughout the night. A CPAP machine costs several hundreds of dollars, not including the maintenance, replacement masks and other parts. However, the major issue with CPAP machines is non-compliance; despite the high efficacy of CPAP machines, people tend to abandon use (Weaver & Grunstein 2008). People abandon use of their CPAP, presumably because of the relative invasiveness of the mask and the machine itself. Because of non-compliance of CPAP machines, the development of better treatments for sleep apnea is essential. For this group, measures to increase the quality of their sleep are far more important than simply increasing sleep duration since their sleep time is not being utilized to its full potential.

This paper has omitted a discussion of sleeping aids because only about 4% of adults over age 20 have used prescription sleep aids in the past month (*Prescription Sleep Aid Use Among Adults: Unites States, 2005-2010*, CDC, 2013). Furthermore, policies should not focus on promotion of sleeping aids because long-term use of sleep aids has been linked to adverse health effects. It is important to note, however, that economic pressures increase the use of prescription sleep aids (Cascade et al. 2009). This further suggests that economic pressures have a significant influence on sleep habits and sleep health.

Increase awareness of dangers of short sleeping among the public and healthcare professionals

Policy changes must be made to increase public and professional awareness about sleep and sleep disorders. In 2004, there were only 151 researchers primarily involved in clinical sleep research and only 54 individuals received doctorates with a focus on sleep medicine (Colten & Altevogt 2006). It is essential to increase these numbers in order to achieve a more sleep-cognizant and healthy society. In addition to a lack of physicians who are sleep medicine specialists, the majorities of doctors do not have adequate education or training in the treatment of sleep and sleep disorders (Colten & Altevogt 2006). As indicated in the literature review, everything aspect of human function gets worse with poor sleep; sleep is restorative and is essential for adequate function and health of the brain and the rest of the body. An increase in awareness, education, and training among health care professionals is crucial (Colten & Altevogt 2006). Additionally, teaching hospital staff the importance of sleep is essential in reducing treatment time because our immune systems are highly influenced by sleep. (Opp 2005). As suggested by Yoder et. al. (2012), if patients have healthier, undisturbed sleep in the hospital they will get better faster and be discharged sooner. This could lead to a decrease in hospital stay length and lower medical costs.

Perhaps one of the most dangerous aspects of short sleeping is the tendency for individuals not to recognize cognitive difficulties and consequences of poor sleep habits. While lack of sleep can have similar effects to alcohol intoxication, we cannot perceive our states of alertness as well as we think (Van Dongen et. al. 2003).

In conclusion, increasing awareness of the benefits of sleep and the short and long term negative effects of short sleeping is crucial. Policies that promote healthy sleep habits could

include an increase in public warnings about the dangers of short sleeping in addition to an increase in professional and public education regarding sleep. Policy measures exist to decrease smoking and drug abuse because of their negative effects; similar policies encouraging sleep and rest are essential to reducing economic loss due to poor sleep.

Workplace support of good sleep

Notably, workplace support of good sleep in the medical profession and in other high cost of error occupations is essential. Decreasing medical interns' work hours and eliminating extended work shifts reduced the number of serious medical errors by 35.9% as a result of greater rest (Landrigan et. al. 2004). Long and irregular shifts increase the probability of error. Both the employer and the employee must know the dangers of shift-work and efforts to mitigate the effects of rotating shifts on physical health should be undertaken.

Recently, companies such as Google, Proctor and Gamble, and the Huffington Post have implemented "nap rooms" to increase worker productivity (Stump 2013). Americans tend to value hard workers, but sleepy workers can decrease productivity and lead to dangerous circumstances as a result of delayed response times and cognitive impairments. These recent steps towards improving employee sleep habits could greatly benefit society and lower economic losses attributable to poor sleep. If private companies such as Google are implementing these strategies to increase worker productivity, the government should reward and further encourage such changes because they improve individual health and lower the risks of accidents in addition to increasing worker productivity.

Conclusion

The health of American society is gravely threatened by trends in the curtailment of sleep. Poor sleep has direct negative effects on body function that increase risks of heart disease, diabetes, and accidents, three leading causes of death in the United States. It is likely that the vicious cycle of spoor sleep leading to disease and health problems, that further worsens sleep quality and causes pathological sleep disorders, is responsible for a significant, if not enormous, proportion of the country's healthcare spending. Furthermore, inadequate sleep worsens already prominent public health problems that account for an enormous percentage of health care spending. Public policies must be enacted to improve the quantity and quality of sleep of individuals, facilitating a safer, healthier and more productive society as well as

lowering health care costs. Increasing public and healthcare professionals' awareness of the importance of sleep is essential.

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