



Teenagers: decoded The Link Between Sleep, Health and Behavior

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Overview

- Importance of sleep as a health imperative
- Developmental changes in sleep and circadian biology in adolescents
- Impact of sleep loss on student health, safety, and function
- What schools, parents, and students can do
- Principles of healthy sleep

Myths and Misconceptions

- Teens would go to sleep earlier if their parents just made them do it
- Some teens might need 9 hours of sleep, but mine does just fine with 6 (and so do I!)
- Take the cell phones (TV, laptops, tablets) away and kids will fall asleep
- If school starts later, they'll just stay up later
 - And if school lets out later, they'll have to cram in the same amount of stuff in even less time
- Teens can just make up lost sleep by sleeping late on weekends or going to school later one day/wk
- Kids need to learn to get up early; that's real life
- They'll survive

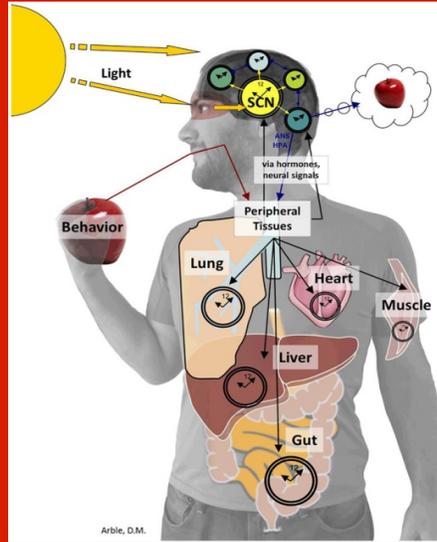
The Importance of Sleep

- Sleep is essential to health, safety, productivity and well being
- A sufficient amount to meet sleep needs *and* appropriately-timed sleep is as important as nutrition and exercise
- The only thing that replaces sleep is:
SLEEP



Both Sleep Time and Sleep Timing are “Biological Imperatives”

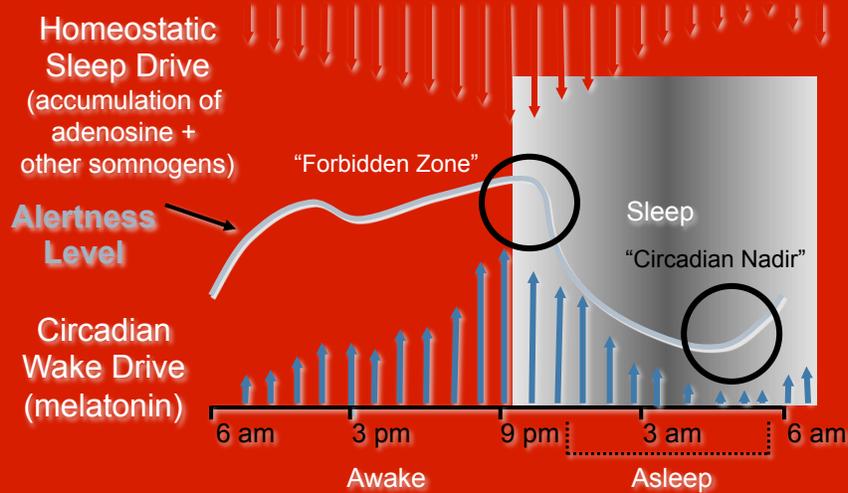
In addition to a “master clock” in the brain, each cell in the body possesses a “circadian oscillator”/ “clock” which must be synchronized with one another and the environment



“Misalignment” between internal circadian clocks and the external light-dark cycle results in profound impairments in physiologic function and health

Arble, D.M. Frontiers in Neuroscience, 2013

“Two Process” Model of Sleep Regulation



Now, imagine all of this shifting later by 2 hours...

Adolescent Sleep: The "Perfect Storm"?



*Includes middle and high school students

Sleep in School-Aged Children

- Total sleep time: 10-12 hours
- Low level of daytime sleepiness
 - Racial/ethnic differences napping
- Circadian preference (chronotype): owl vs lark*
- School, activities, electronic media ® later bedtimes, earlier rise times, irregular sleep/wake schedules
- Less parental awareness of sleep issues



*But most younger children have a "morningness" preference

Sleep in Adolescents: Later Bedtimes

- All adolescents experience a normal shift in circadian rhythms with age and in association with the onset of puberty
- This results in a biologically-based shift (delay) of up to several hours in both the natural fall sleep and morning wake times
- On a practical level, due to the “forbidden zone” this means that it’s almost impossible for the average adolescent to fall asleep much before 11pm on a regular basis
- Teens cannot “make” themselves fall asleep earlier

Sleep in Adolescents: Later Bedtimes

- Environmental factors
 - Competing priorities for sleep: homework, activities, after-school employment, “screen time”, social networking
 - Circadian phase delay may be further exacerbated by evening light exposure
 - Suppresses brain release of melatonin



Adolescents: Later Wake Times

- These biological changes are in direct conflict with earlier high school start times (before 8:30am) because adolescents are biologically programmed to wake at 8am or later
- As a result, students are required to wake for the day and function during the “circadian nadir” (the lowest level of alertness during the 24 hour day)
- Early wake times also selectively rob teens of REM (rapid eye movement) sleep, which is critical for learning (*of new information in particular*) and memory

Adolescents: “Make-Up” Sleep

- Increasing discrepancy between bed and wake times weekday/end
 - Associated with learning deficits, behavior problems in school
- Adequate compensation for sleep loss?
 - Does not address compromised alertness on school days
 - Does not reverse performance impairments



“Weekend Oversleep”

- Leads to “circadian misalignment”
 - Exacerbation circadian phase delay
 - Shift melatonin onset
- Prevents sufficient build-up of sleep drive
 - Difficulty falling asleep Sunday night
- Result: permanent state of “social jet lag”
 - Adjustment takes 1 day/time zone crossed
 - Effects persist up to 3 days
 - Associated daytime sleepiness, poor academic performance, depressed mood

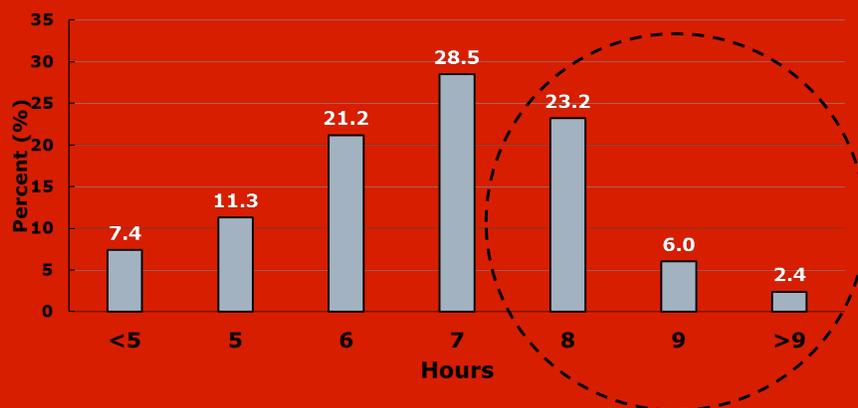


Adolescent Sleep: The Bottom Line

- For optimal health, safety and achievement the average sleep high school student needs: 8.5-9.5 hours of sleep
 - 2016 AASM recommendations 8-10 hours for 13-18yo*
 - 9 to 12 hours for children 6-12 years
- In the 10th largest school district in the country (n=40,000+ high school students) (2010-12):
 - Only 6% of 10th and 3% of 12th graders get ≥ 9 hours
 - 42% of 10th and 56% of 12th graders report < 6 hours

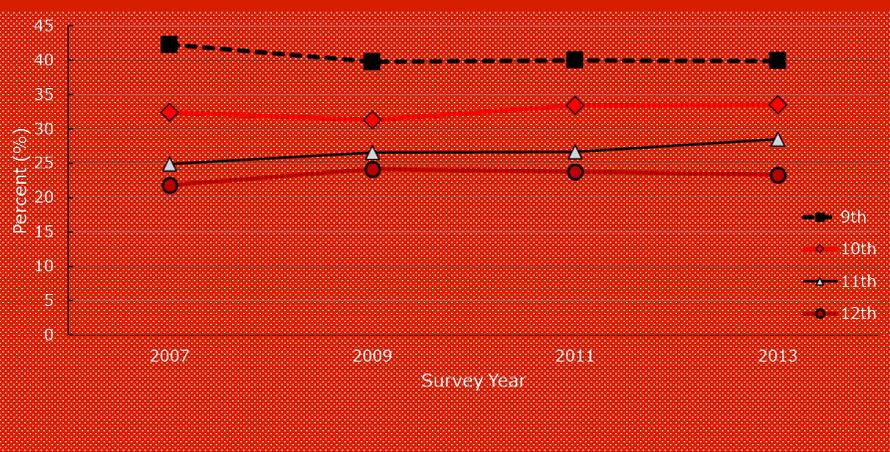
**Based on 10 month review by 13 sleep experts of published scientific evidence addressing the relationship between sleep duration and health (total of 864 scientific articles)*

Distribution of Sleep Durations among 12,050 High School Students: US, 2013



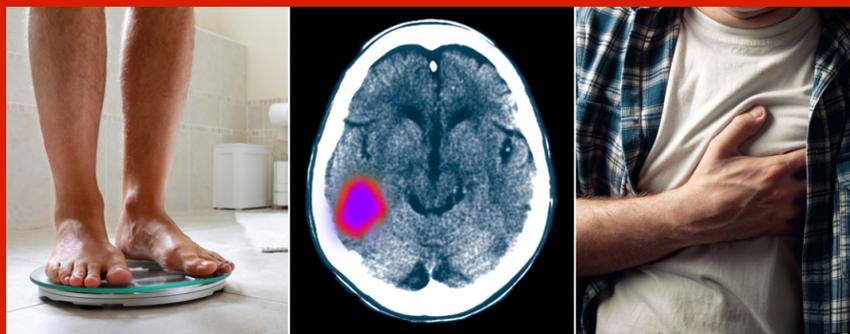
Data Source: CDC. National Youth Risk Behavior Survey (YRBS) 2013

Percent of High School Students who Report Sleeping ≥ 8 hours/school nights, by Grade: United States, 2007-2013

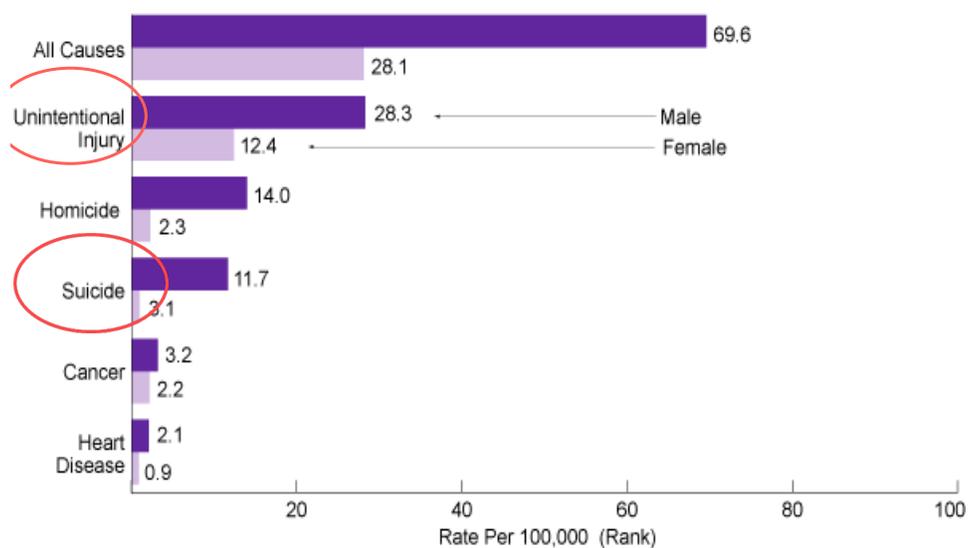


Data Source: CDC. National Youth Risk Behavior Surveys (YRBS) 2007-2013

Effects on Performance, Health and Safety



Mortality Rates Among Adolescents Aged 15–19 Years, by Selected Leading Cause of Death 2010



Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2010. CDC WONDER Online Database, compiled from Compressed Mortality File 1999-2010 Series 20 No. 20, 2012. Retrieved from: <http://wonder.cdc.gov/ucd-icd10.html>. Accessed: November 15, 2012.

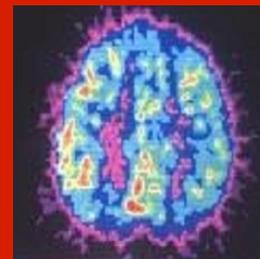
Neuroprotective Role of Sleep

- Sleep deprivation/prolonged wakefulness affects neuronal functions
 - Neuronal “plasticity”: ability of the brain to change structure and function in response to the environment
 - Gene activation/expression
 - Brain cell protection/repair from stress
 - Highest susceptibility during critical developmental periods
- Recent research has found evidence of a “glymphatic system” which eliminates toxins in the brain during sleep and allows the brain to have a “clean slate” from which to work
- Sleep deprivation/prolonged wakefulness increases the stress response and stress hormones



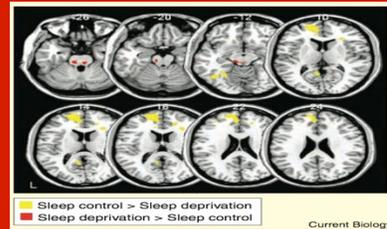
Sleep and Behavioral Self-Regulation

- Experimental sleep restriction has selective effects on the prefrontal cortex (PFC) and “executive functions”
 - Flexibility
 - Planning
 - Problem-solving
 - Decision-making
 - Divergent thinking
 - Cognitive set shifting
 - Judgment, motivation
 - Monitoring, modifying and inhibiting behavior
 - Modulation of emotions
- Rapid development in adolescence



Sleep and Emotional Regulation

- Sleep impacts response to positive and negative stimuli:
 - Increased response of the “emotional brain” (limbic system/ striatum)
 - Weaker PFC connectivity
 - Heightened emotional response with less regulatory control



Guyar et al, 2007; Helm et al 2011

Sleep and Mood

- Adolescents who are sleep deprived are much more likely to report depression, and more likely to have suicidal thoughts
- Youth Risk Survey (2010-12)
 - 40% of teens getting less than 6 hours of sleep report depression symptoms (sadness, hopelessness)



Sleep and Risk Taking Behaviors

- Selective areas of the brain (striatum) are important for reward-related function
 - Positive emotions
 - Motivation
 - Response to reward
- These undergo structural/functional changes in adolescence
- Studies suggest insufficient sleep linked to changes in reward-related decision making
 - Perceive less negative consequences, take greater risks

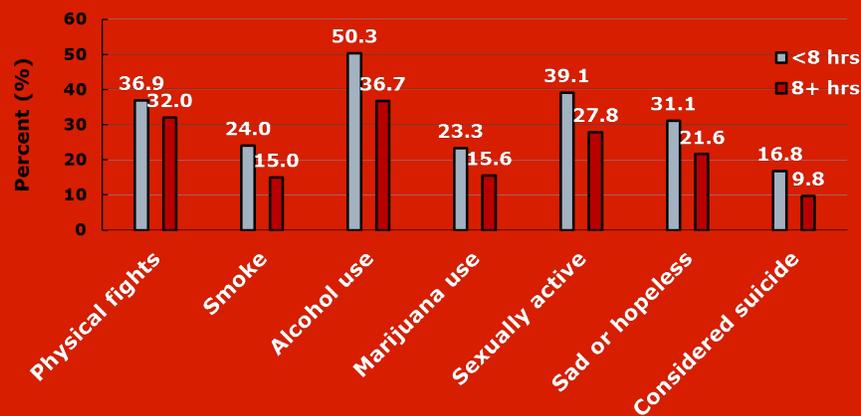


Sleep and Risk-Taking Behaviors

- Sleep duration is a significant negative predictor for alcohol-related problems such as binge drinking, driving while drunk, and engaging in activities while drinking that one later regrets
- Adolescents who obtain the least amount of sleep on school nights report the highest prevalence of alcohol use



Comparison* of Selected Risk Behaviors among 12,154 High School Students, by Sleep Duration: YRBS, 2007



*All comparisons significant at $p < 0.05$.

Adapted from McKnight-Eily LR et al. *Preventive Medicine* 2011;53:271-273.

Sleep-Starved?

- Multiple studies suggest shorter sleep amounts associated increased risk of obesity
- Sleep duration and timing affect:
 - Hunger
 - Food intake: increased amount, more calories, more fat
 - Eating patterns (skipping breakfast, increased night eating)
 - Physical activity
 - Cardiovascular function
 - Insulin metabolism and increased diabetes risk
- Sleep apnea more common in obese children, further compromising cardiovascular and metabolic health



Caffeine (and Other Drugs)



- Association of early coffee use (≤ 12 yo) with later use illicit drugs and alcohol
- Low risk vs high (>6 cups/mth) 7th grade users 1.5-2.5x less likely to use ETOH, tobacco at 1 yr f/up
- Association twin studies alcohol/cigarettes
 - Caffeine increases reinforcing effects nicotine; increased caffeine metabolism smokers
- Possible role as “gateway drug?”
 - Energy drink consumption college students predicts subsequent non-medical stimulant use



Sleep and Safety: Accidental Injuries

- Drowsy driving:
 - Drivers 16-25 years are involved in more than 50% of the 100,000 police-reported fatigue-related traffic crashes each year
 - National poll: 68% of HS seniors have driven while drowsy; 15% at least 1x/wk
 - Sleep loss impairments are equal or greater than those due to alcohol intoxication (ie, 3-4 beers)
- Sleep loss is associated with an increased risk of pedestrian injuries in children
- Sleep loss is associated with increased sports-related injuries in high school students
- Sleep loss is associated with almost 3x risk in adolescents of work-related injury requiring medical care

Can Lack of Sleep Be Fatal?

- In adults, short sleep duration is associated with significantly greater risk of all-cause mortality (death due to any cause)*; U-shaped curve
- First prospective cohort study of childhood sleep duration and life-long mortality risk (2009) in a sample of healthy children followed from childhood throughout their entire lives**
 - Eg, 16-year old male participants sleeping 3 hours less than the average (predicted) amount for their peers were at 2.34 times the all-cause mortality risk

Finding Common Ground



What Can Parents Do?

- Know the signs of insufficient sleep in children and adolescents
- Provide a “sleep-friendly” home environment
- Establish limits on after-school activities and jobs
- Be a good sleep role model
- Make sleep a priority!
- Prevent drowsy driving:
 - “No ZZZs, no keys”
- Limit caffeine use



What Can Parents Do? Caffeine

- Be aware of amounts and possible sources of caffeine
- Monitor your child’s caffeine intake
- Develop a plan to cut down
- Be a good role model
- Encourage caffeine-free beverages; herbal alternatives
- Do not allow caffeine use as a substitute for sleep!



Students' Guide to Good Sleep

- Practices Promoting Sleep Regulation (Circadian and Sleep Drive)
 - Maintain a consistent sleep–wake cycle (ie, bedtime and wake time weekdays and weekends)
 - Keep a regular daily schedule of activities, including meals
 - Avoid bright light in the bedroom at bedtime and during the night
 - Increase light exposure in the morning

A Word about Napping

- When is a nap helpful?
 - When it is not possible to get sufficient sleep at night
- What time of day is best?
 - Late afternoon ('circadian trough')
- How long should a nap last?
 - 30 minutes or less to avoid "sleep inertia"
- What are the real benefits?
 - Short-term alertness improvement
 - But NOT a long-term substitute for getting enough sleep!



Students' Guide to Good Sleep

- Practices Promoting Sleep Conditioning
 - Establish a regular and consistent bedtime routine
 - Limit activities which promote wakefulness while in bed (texting, doing homework); use the bed for sleep only
 - Avoid sleeping in environments other than the bedroom (couch, car)

Students' Guide to Good Sleep

- Practices Reducing Arousal and Promoting Relaxation
 - Keep electronics out of the bedroom and limit use of electronics before bedtime
 - Avoid heavy meals and vigorous exercise close to bedtime
 - Reduce cognitive and emotional stimulation before bedtime
 - Eliminate caffeine after 6pm
 - Include activities in the bedtime routine that are relaxing and calming



Students' Guide to Good Sleep

- Practices Promoting Adequate Sleep Quantity and Quality
 - Set a bedtime and wake time to ensure adequate sleep (know the numbers!)
 - Maintain a safe and comfortable sleeping environment (low noise and light levels, cooler temperatures, age-appropriate bedding and sleeping surface)



What Can Schools Do?

- Emphasize sleep as a health priority
- Educate school personnel – health services personnel, faculty, coaches, administrators, school counselors about the importance of sleep
- Include sleep as part of student health education, biology classes (NCSDR curriculum)
- Include drowsy driving in driver ed
- Eliminate caffeinated beverages in vending machines



What Can Schools Do?

- Help students manage their schedules so that they have time for adequate sleep
- Consider homework burden
- Buffer early start times by setting limits on evening activities at school as well as early morning/ late evening athletic practices
- Set healthy school start times for middle and high school students (8:30am or later)

AAP Recommendation: Delay School Start Time until 8:30 am or Later

American Academy
of Pediatrics



DEDICATED TO THE HEALTH OF ALL CHILDREN™

Let Them Sleep: AAP Recommends Delaying Start Times of Middle and High Schools to Combat Teen Sleep Deprivation

8/25/2014

For Release: August 25, 2014

Studies show that adolescents who don't get enough sleep often suffer physical and mental health problems, an increased risk of automobile accidents and a decline in academic performance. But getting enough sleep each night can be hard for teens whose natural sleep cycles make it difficult for them to fall asleep before 11 p.m. – and who face a first-period class at 7:30 a.m. or earlier the next day.

Pediatrics 2014;134:642-649.

Brief History of SSTC

- Minnesota pioneers
 - 1996: Edina MN changed high school start times from 7:20am to 8:30am
 - 1997: Minneapolis changed high school start times from 7:15am to 8:40am; N>18,000 students
- Since late 1990's, ~1000 high schools in >100 districts in 43 states report school start time delays; almost no schools have returned to the original bell times

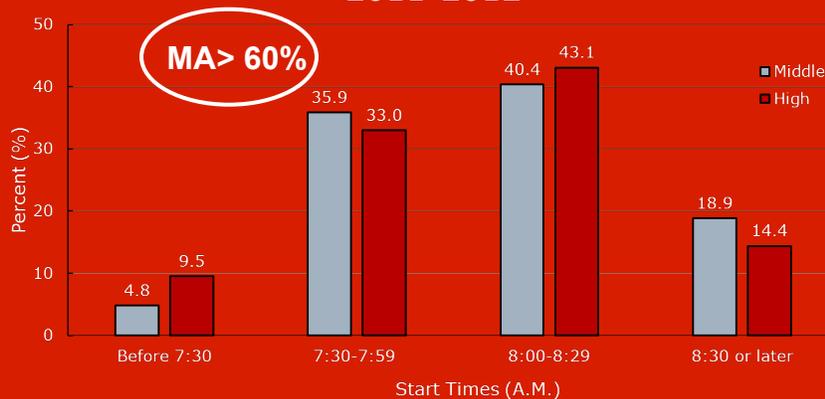


Brief History of School Start Times

- BUT less than 1 in 5 middle and high schools in the US (N=40,000) start at the recommended 8:30am or later*
 - Impacts over 20 million students
- In **MA**, average SST is 7:53am and only 11.5% of public middle and high schools start at 8:30am or later*
 - Over 60% before 8am
- Students in earlier starting schools more likely to belong to an ethnic minority, be eligible for free lunches and have less educated parents

*MMWR 2014

Distribution of School Start Times for US Public Middle and High Schools: US Department of Education Schools and Staffing Survey, 2011-2012



Wheaton AG et al. *MMWR* 2015;64(30):809-813

Outcomes: Sleep*

- Bedtimes remain the same or in some studies actually shift earlier
- Students obtain significantly more sleep
 - More morning sleep
 - The later the start time, the greater the sleep amounts
 - But even a 30 minute delay results in improvements
- Students report less daytime sleepiness (falling asleep in class, doing homework)

*Wheaton AG et al. *J School Health* 2016
Review of 38 reports examining the association between school start times, sleep, and behavioral, health and academic outcomes among adolescent students

Outcomes: School Performance*

- Attendance improves
- Tardiness rates drop
- Drop-out rates decline
- Standardized test scores improve
 - In one study SAT scores for the top 10% of students increased by more than 200 points
- Grades improve
 - 5/6 schools showed significant increase in GPA pre-post in English, math, science and SS
 - Disadvantaged students may benefit more
 - Larger effects of start times at lower end grade distribution**
 - Effects of 1st period classes larger for black students***

Wheaton AG et al 2016 **Edwards 2012 *Cortes et al 2012*

Outcomes: Health & Safety

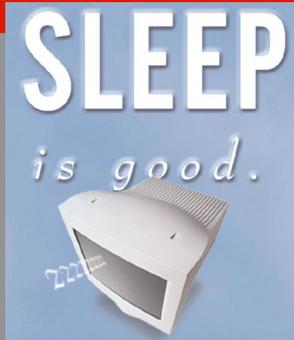
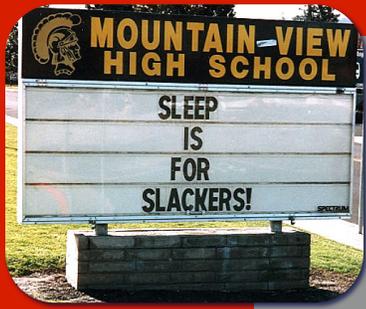
- Delayed SST are associated with improvements in:
 - Mood (fewer report feeling unhappy, depressed)
 - Health (decreased health center visits)
 - Safety
 - Kentucky: 7:30 to 8:40a start time; teens involved in car crashes down by 16% (vs 9% increase in the rest of the state)
 - Virginia: Adolescent crash rates VA Beach (7:20a) vs Chesapeake (8:40a) 40% higher and peak 1 hour earlier
 - CDC study (2014): Reduction crash rates in 16-18yo by as much as 65-70% (Minnesota, Colorado, Wyoming)

Outcomes: \$\$\$

- Brookings Institute Report: “Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments” (2011)
- Moving school start times one hour later would have a substantial benefit: cost ratio (9:1)
 - Based on a conservative estimate of both costs per student (\$0-\$1950; largely related to transportation), and the increase in projected future earnings per student in present value due to test score gains (approximately \$17,500)
- “A later start time of 50 minutes in our sample has the equivalent benefit as raising teacher quality by roughly one standard deviation”

Challenges to Change

- COST \$\$\$
- Curtailed time for athletic practices and interference with scheduling of games
- Reduced after-school employment hours for students
- Challenges in providing childcare for younger siblings
- Adjustments in family schedules
- Potential safety issues and impact on sleep duration in younger children if elementary school schedules are “flipped” with those of middle/high school students
- Need to make alternative transportation arrangements



Thank you! Comments/Questions?