

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

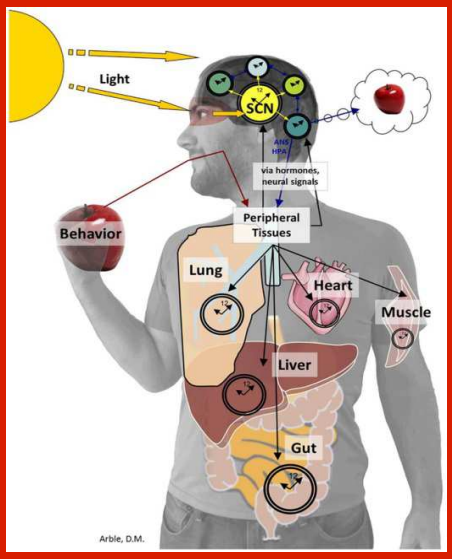
- Sleep is essential to health, safety, productivity and well being
- A sufficient amount to meet sleep needs *and* appropriately-timed sleep is as important as nutrition and exercise
- The only thing that replaces sleep is:

  SLEEP



Both Sleep Time and Sleep Timing are "Biological Imperatives"

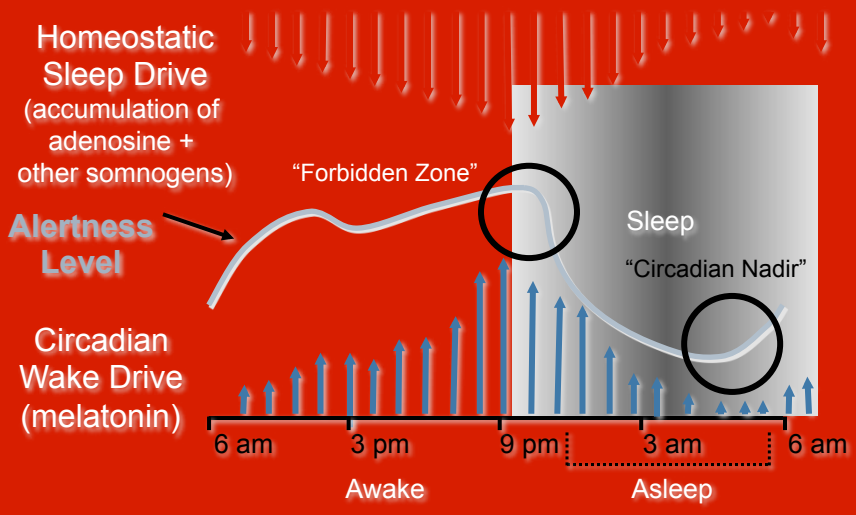
In addition to a "master clock" in the brain, each cell in the body posses a "circadian oscillator"/ "clock" which must be synchronized with one another and the environment



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

Frontiers in Neurocience, 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

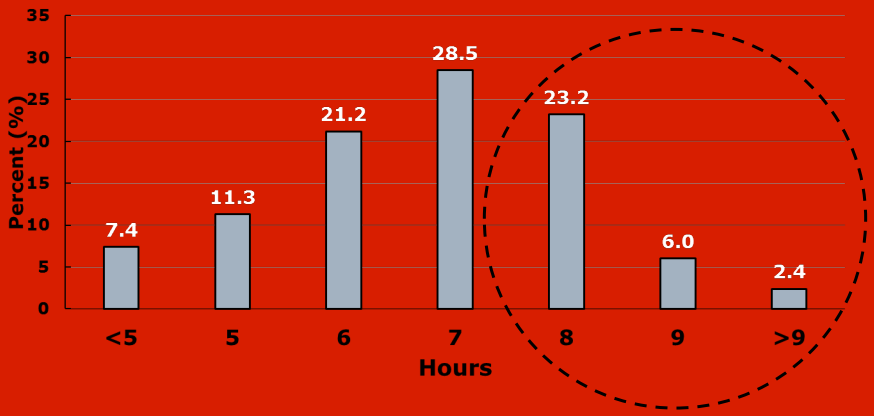


Adolescent Sleep: The Bottom Line

- 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

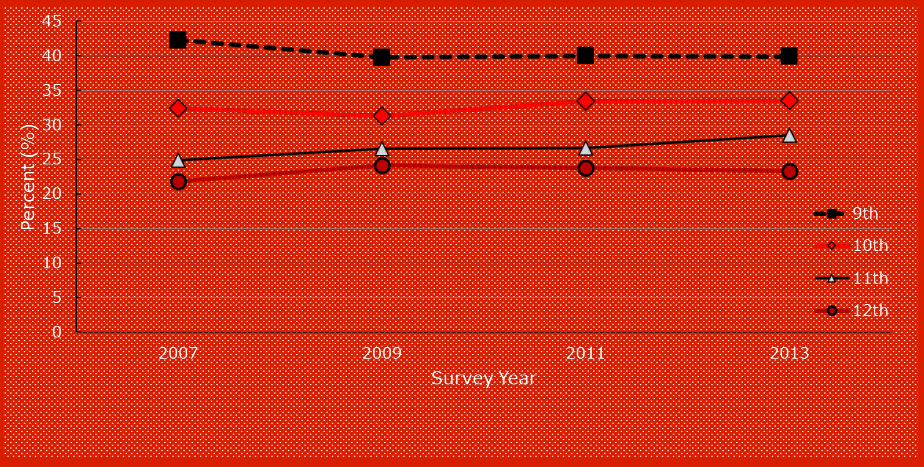
**Based on 10 month review by 13 sleep experts of published scientific evidence addressing the relationship between sleep duration and health (total of 864 scientific articles)*

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



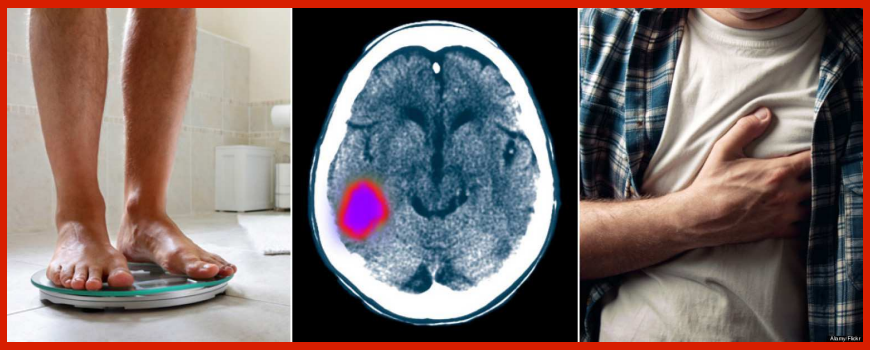
Data Source: CDC. National Youth Risk Behavior Survey (YRBS) 2013

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

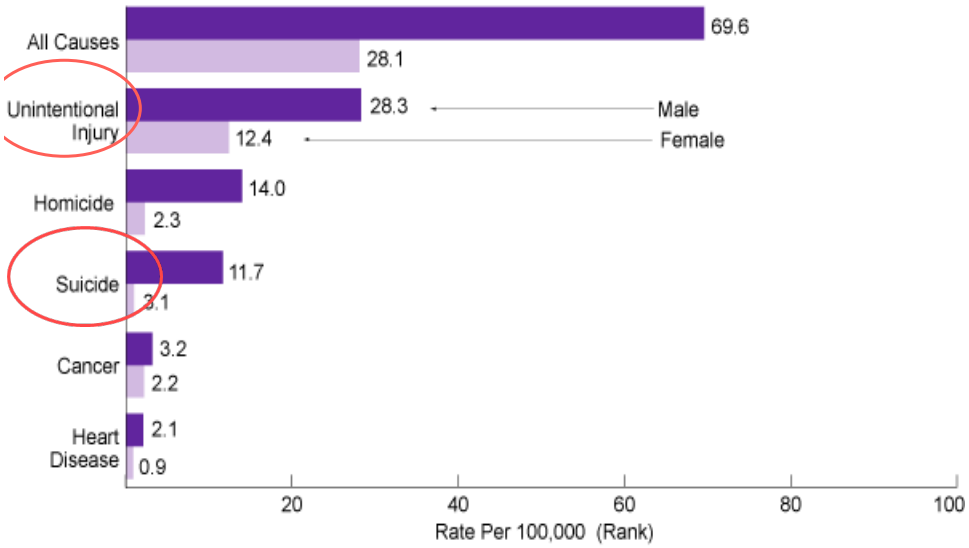


Data Source: CDC. National Youth Risk Behavior Surveys (YRBS) 2007-2013

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. 2O, 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 s function in response to the environment
  - Gene activation/expression
  - Brain cell protection/repair from stress
  - Highest susceptibility during critical developmental periods

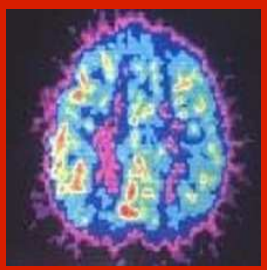


- Recent research has found evidence of a "glympathic system" which eliminates toxins in the brain during sleep and allows the brain to have a "clean slate" from which to work
- Sleep deprivation/prolonged wakefulness increases the stress response and stress hormones

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

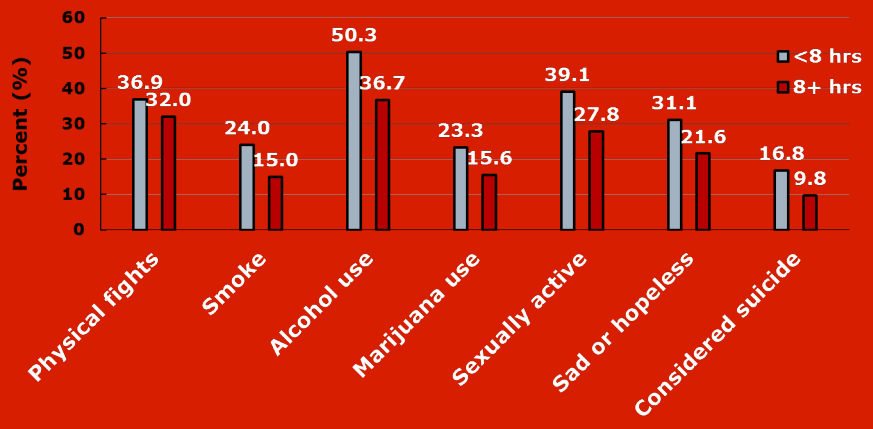


Sleep and Risk-Taking Behaviors

- Sleep duration is a significant negative predictor for alcohol-related problems such as binge drinking, driving while drunk, and engaging in activates while drinking that one later regretted
- 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 (≤12yo) 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



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

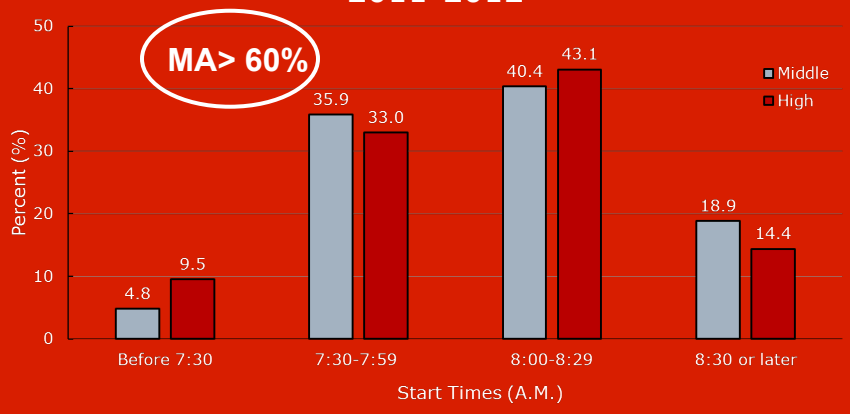


Brief History of School Start Times

- 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

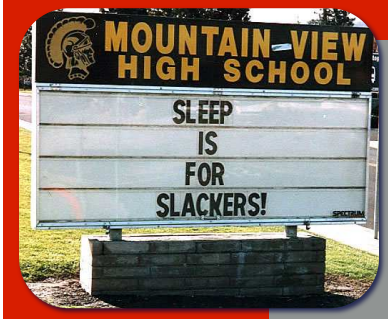
- Delayed SST are associated with improvements in:
  - Mood (fewer report feeling unhappy, depressed)
  - Health (decreased health center visits)
  - Safety
    - Kentucky: 7:30 to 8:40a start time; teens involved in car crashes down by 16% (vs 9% increase in the rest of the state)
    - Virginia: Adolescent 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: $$$

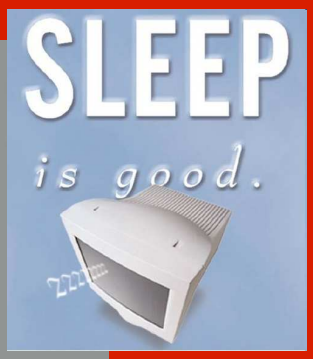
- Brookings Institute Report: "Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments" (2011)
- Moving school start times one hour later would have a substantial benefit: cost ratio (9:1)
  - Based on a conservative estimate of both costs per student ($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?