



# The ABCs of ZZZs: The Impact of Sleep on Student Health and Performance

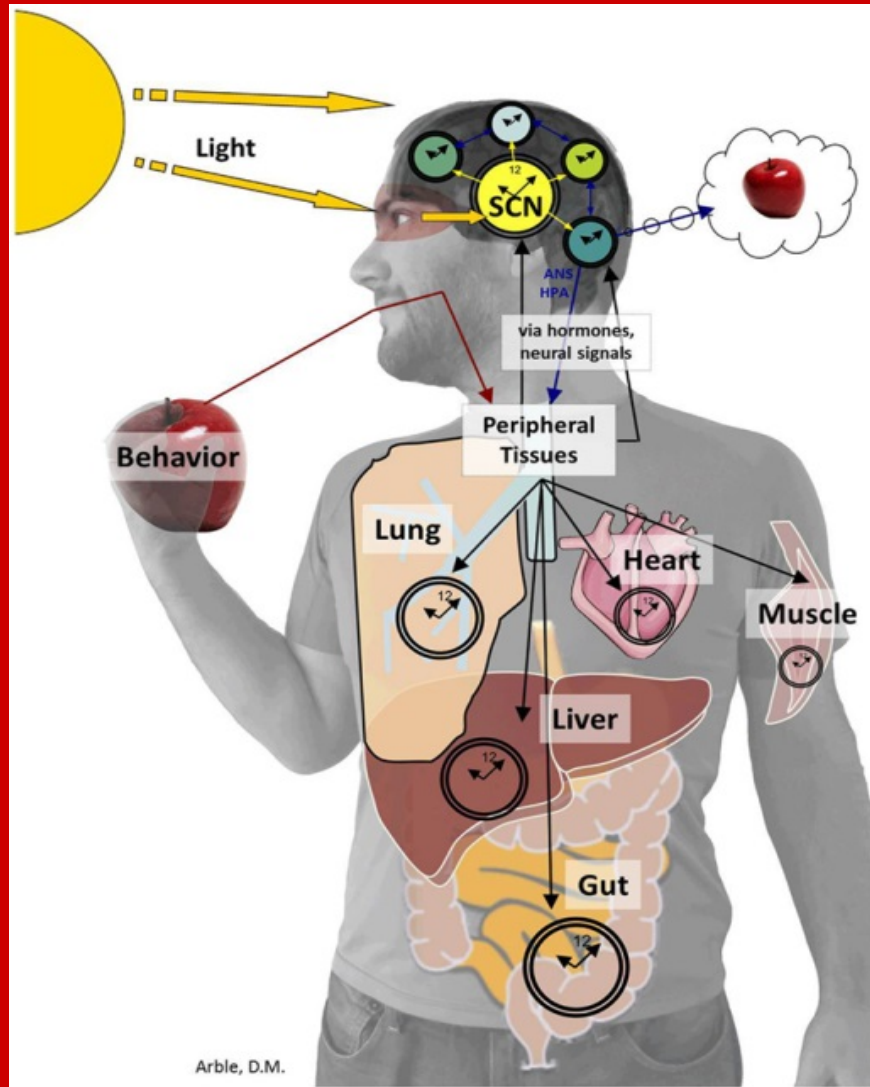
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# Myths and Misconceptions

- 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

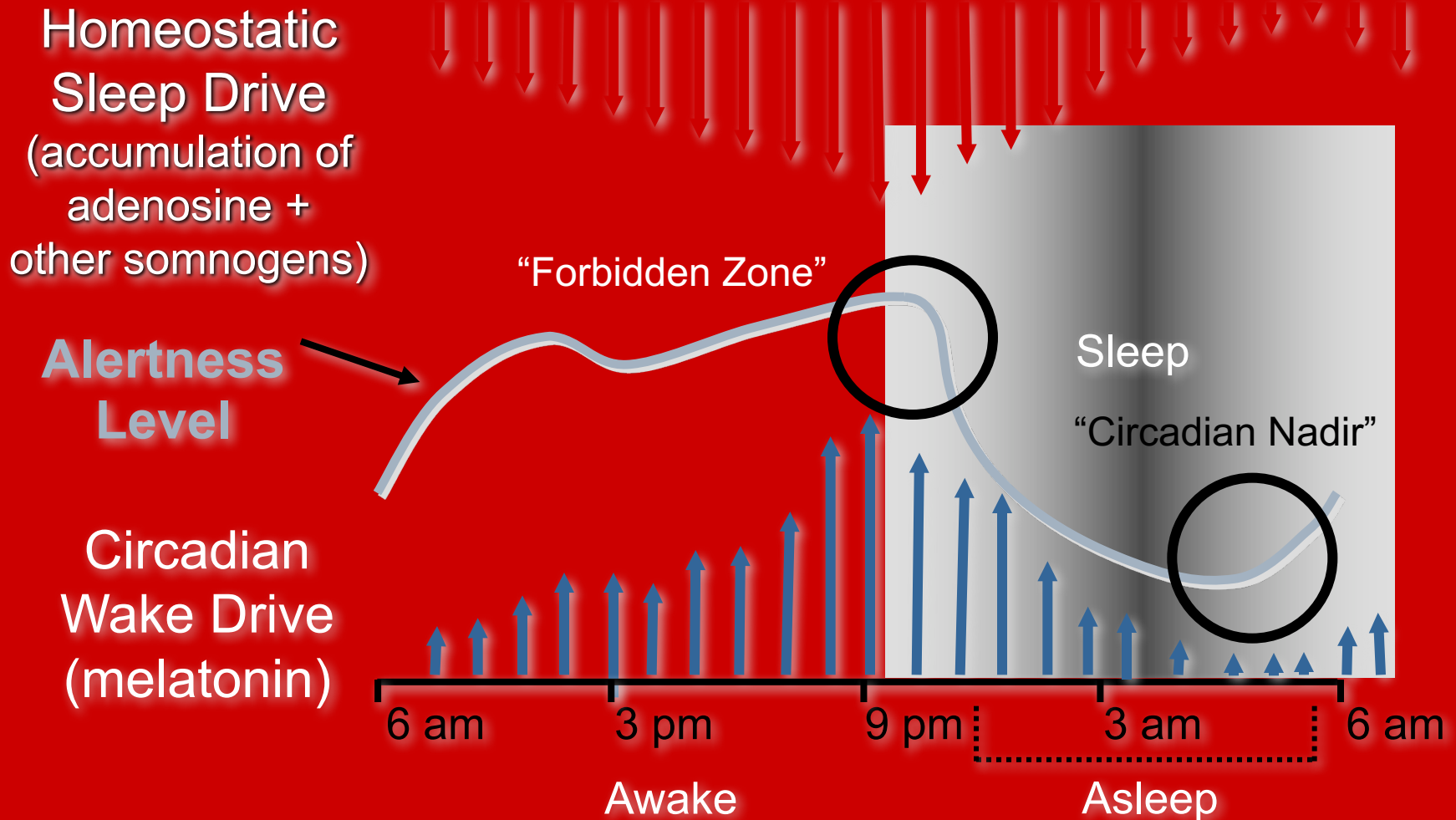
# Both Sleep Time and Sleep Timing are “Biological Imperatives”

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

# “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 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

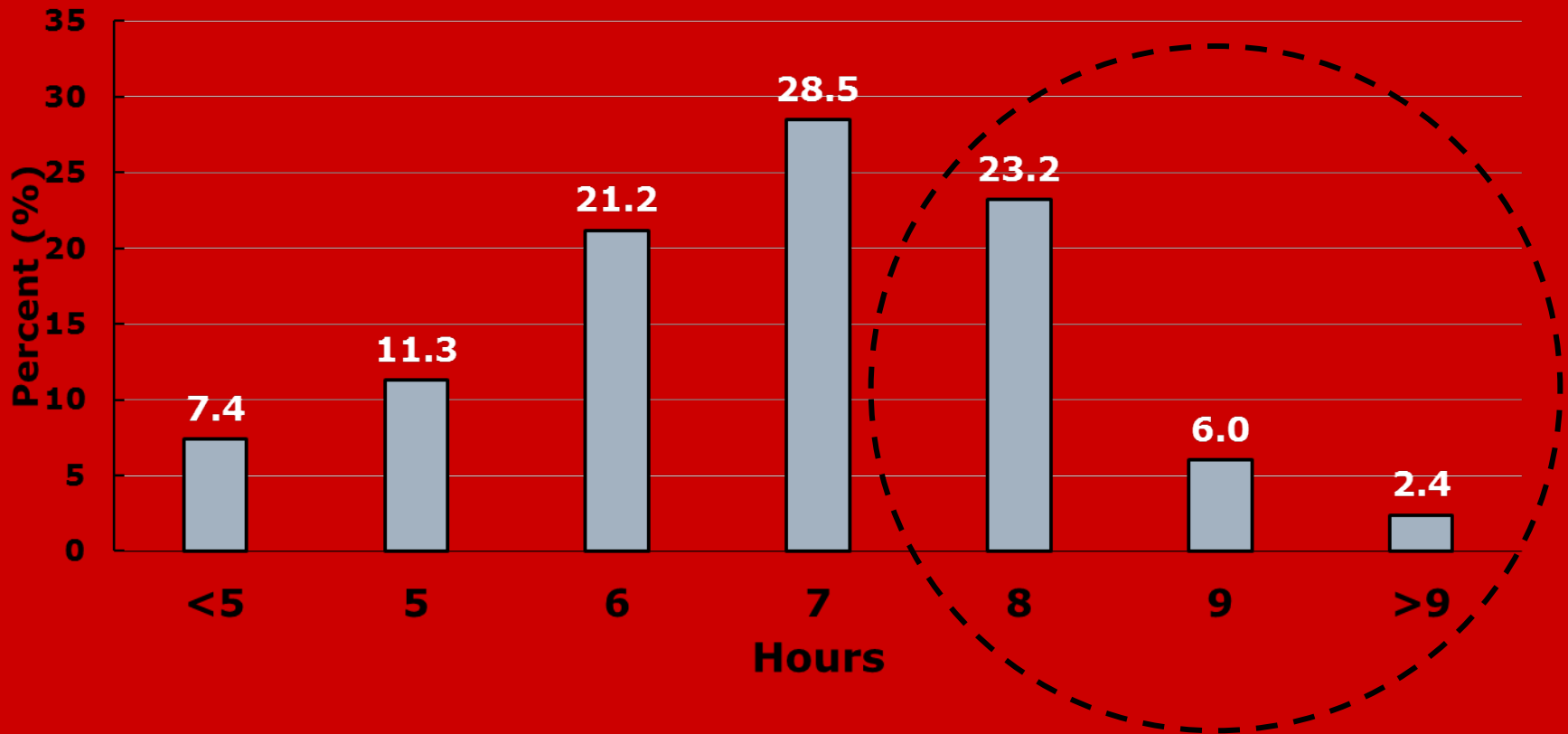


# Adolescent Sleep: The Bottom Line

- For optimal health, safety and achievement the average middle and high school student needs: 8-10 hours of sleep\*
- In Massachusetts:
  - At Algonquin Regional High School, 52% of students surveyed got < 6 hours of sleep/school night (2014)
  - 82% of Masconomet Regional students surveyed get  $\leq 7$  hrs of sleep (2016):
    - 41%  $\leq 6$ hrs
    - 18.2% recommended 8-10 hrs

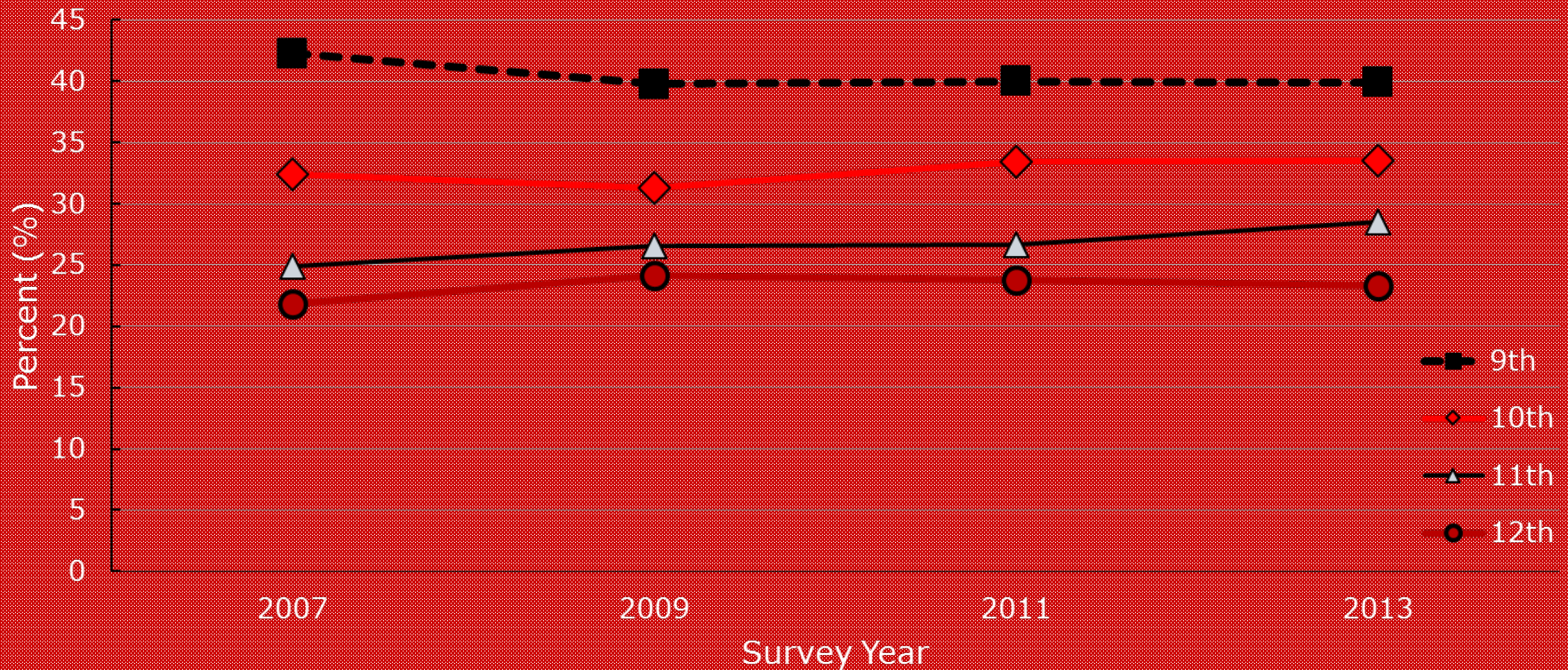
*\*2016 AASM recommendations based on 10 month review by 13 sleep experts of published scientific evidence addressing the relationship between sleep duration and health (total of 864 scientific articles)*

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



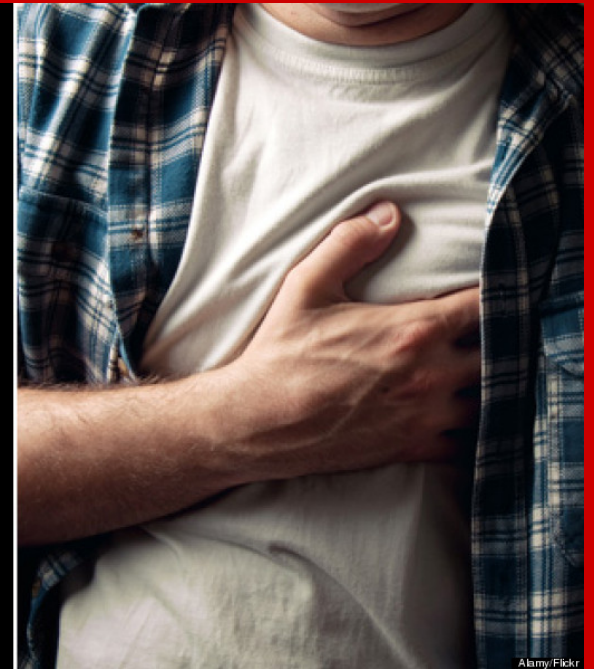
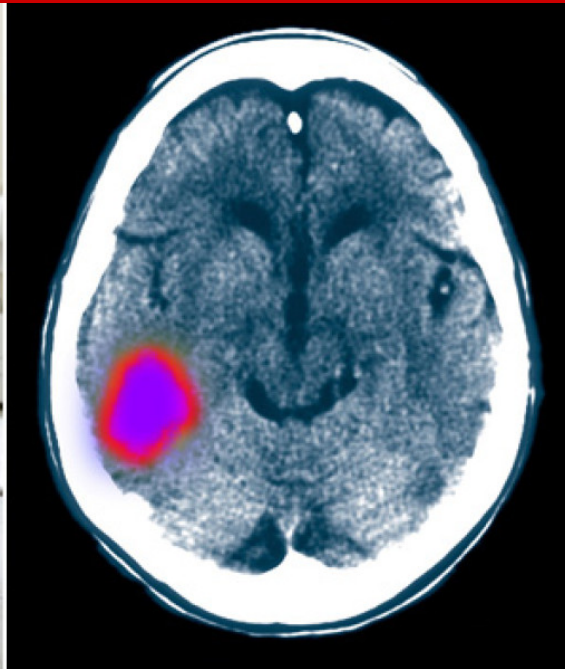
Data Source: CDC. National Youth Risk Behavior Survey (YRBS) 2013

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

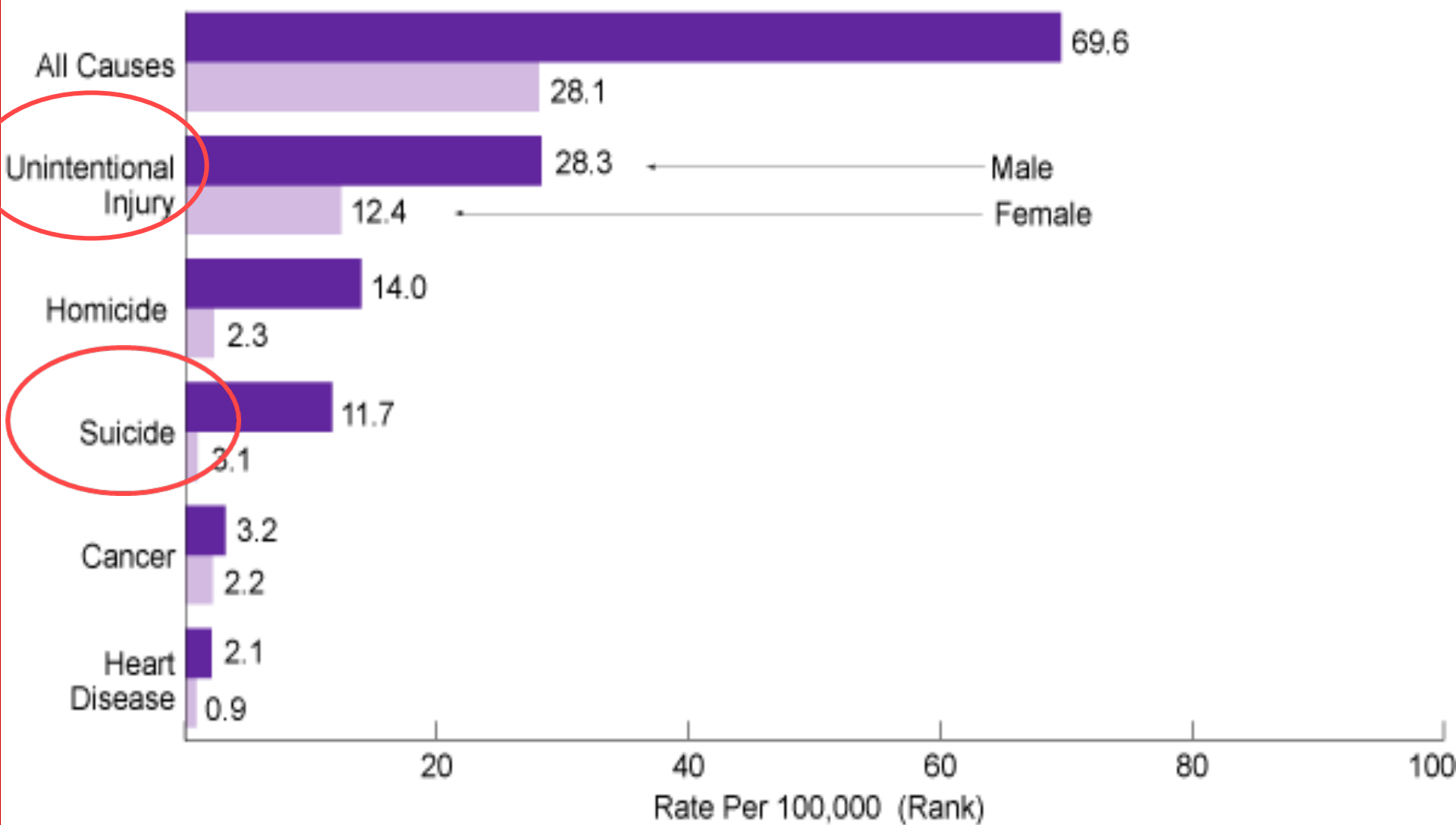


Data Source: CDC. National Youth Risk Behavior Surveys (YRBS) 2007-2013

# Effects on Performance, Health and Safety



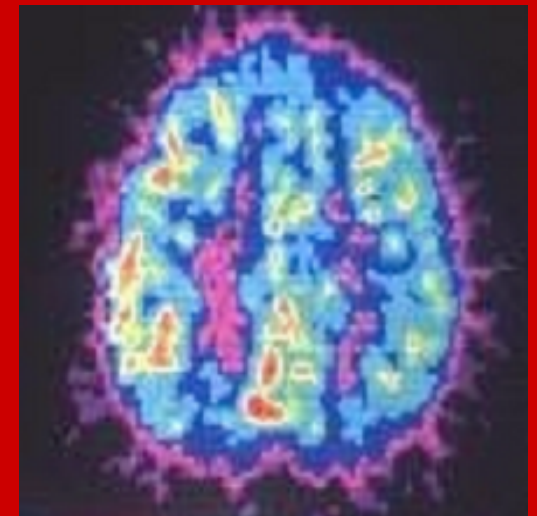
# Mortality Rates Among Adolescents Aged 15–19 Years, by Selected Leading Cause of Death 2010



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.

# Sleep and Behavioral Self-Regulation

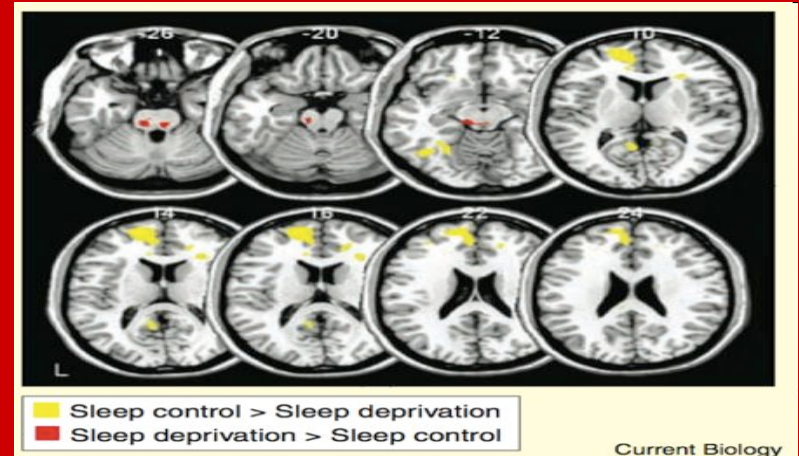
- Experimental sleep restriction has selective effects on the prefrontal cortex (PFC) and “executive functions”
  - Flexibility
  - Planning
  - Problem-solving
  - Decision-making
  - Divergent thinking
  - Cognitive set shifting
  - Judgment, motivation
  - Monitoring, modifying and inhibiting behavior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



# 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 regretted
- Adolescents who obtain the least amount of sleep on school nights report the highest prevalence of alcohol use



# 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



# 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

# 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,  $\sim 1000$  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\*
- In **MA**, average SST in 2015 for public middle and high schools was 7:37am (from 7:53am 2011-12) and only 2 schools (1%) of start at 8:30am or later\*
  - >80% start 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 2015

# 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)
- ≥8:30am the sleep and circadian “sweet spot”?

\*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 1<sup>st</sup> 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”

# Outcomes: \$\$\$

- RAND Corporation report (2017)\*
  - Potential *significant economic gains of a state-wide shift in start times to  $\geq 8:30am$*  related to improved academic performance of students resulting in increased lifetime earning potential and reduced car crashes
  - Economic gain [modeled across 47 US states] estimated annual gain of  $\sim$  \$9.3 billion
    - Roughly the annual revenue of MLB
  - Report estimates that MA would see one of the highest cost-benefit ratios in the nation
    - *At minimum breaking even after just 2 years*
    - *Achieving a cost-benefit ratio of 4.5 after 10 years, meaning that for every dollar spent, the return is more than four-fold the cost*

\*Hafner, Marco, Martin Stepanek and Wendy M. Troxel. *Later school start times in the U.S.: An economic analysis.* [https://www.rand.org/pubs/research\\_reports/RR2109.html](https://www.rand.org/pubs/research_reports/RR2109.html).

# 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
- Need to make alternative transportation arrangements
- Potential safety issues and impact on sleep duration in younger children if elementary school schedules are “flipped” with those of middle/high school students

# Elementary School Start Times

- Sleep needs: 9-12 hrs\*
- Circadian preference (chronotype): owl vs lark\*\*
- School, activities, electronic media, later bedtimes, earlier rise times, irregular sleep/wake schedules contribute to deficient sleep
- However, as opposed to adolescents, they are biologically, environmentally and socially more amenable to manipulation of bedtimes (ie, to move sleep onset earlier) if required
- Is there a sweet spot?
  - Data is mixed but suggest 7:30-9am
  - Earlier start times more impact on academics, behavior
  - Issues of civil twilight, safety concerns

\*AASM 2016

\*\*But most school-aged (pre-pubertal) children have a “morningness preference”





# Elementary School Start Times: The “Flip”

- Impact of School Start Time Changes:
- HS students delayed from 7:30am to 8:15am
- Students in grades 3-5 advanced from a start time of 8:20am to 7:45am
- HS students got 35 minutes more sleep
- 3<sup>rd</sup> graders also got more sleep (+24 minutes) after the change
- Sleep duration changes in 4-5<sup>th</sup> graders negligible
- No differences in behavior measures post-change

Grade	SST 1 BT/WT (SD HH:MM)	SST 2 BT/WT (SD HH:MM)	Sleep Duration Difference (Min)
3	8:37p/6:49a (10:11)	8:22p/6:57a (10:35)	+24*
4	8:52p/6:56a (10:03)	8:22p/6:22a (9:59)	-4
5	9:10p/6:59a (9:49)	8:43p/6:23a (9:40)	-9
10	(7:42)	(8:17)	+35**

*Appleman et al. School start time changes and sleep patterns in elementary school students. Sleep Health, 1(2) (2015), 109-114.*

\*Largely accounted for by earlier bedtimes

\*\*Completely accounted for by later rise times; 0 min difference bedtimes

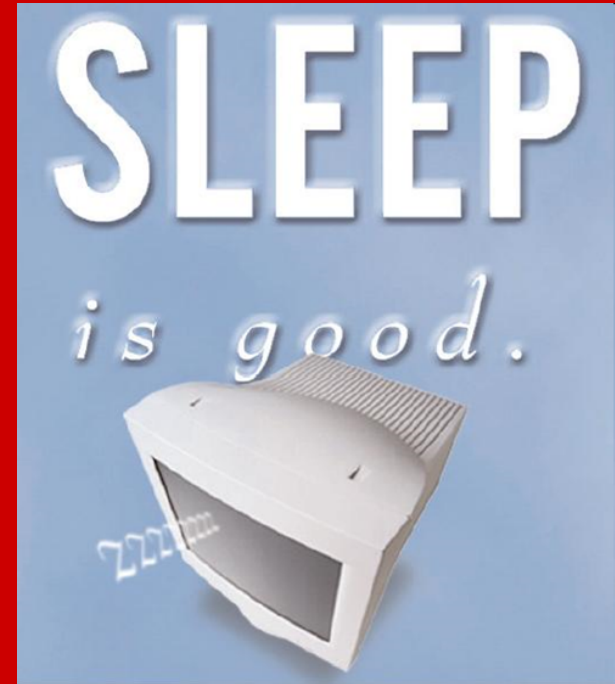
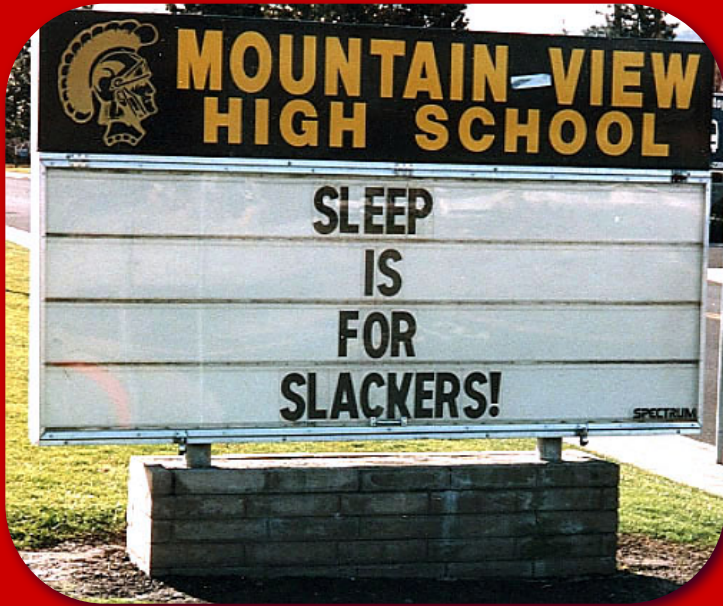
# Lessons Learned

- District superintendent support and leadership critical
- School board involvement key
- School leadership (ie, principals) and teacher support vital
- Importance of middle/elementary school principal, teacher, parent involvement
- Importance of student engagement
- Critical role of community *education*
  - Health, safety *and* academics
- Critical role of community *engagement*
  - Identification and involvement of key stakeholders

# Lessons Learned

- Critical to allow adequate time for families to become informed and make sufficient plans prior to implementation
- Each community faces different, unique challenges
  - But you don't have to "reinvent the wheel"
- Not all students will benefit equally
  - The goal is to provide "the greatest good for the greatest number of students"
- Anticipation often worse than reality (impact on athletics, teacher retention, after-school programs, childcare issues)
- Initial challenges reduced over time

What is your vote?



Thanks for your attention!