Why teens are susceptible to driving fatigue.

Mary A Carskadon, PhD
EP Bradley Hospital Sleep Research Lab
Alpert Medical School of Brown University

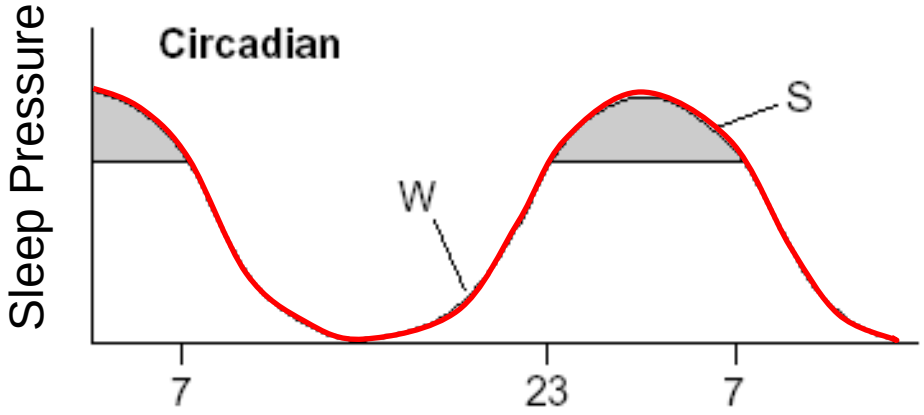
Overview

- Teen biology and sleep
- Teen behavior and sleep
- Teen driving and sleep

Teen biology and sleep

- The circadian timing system
- The sleep-wake homeostatic system

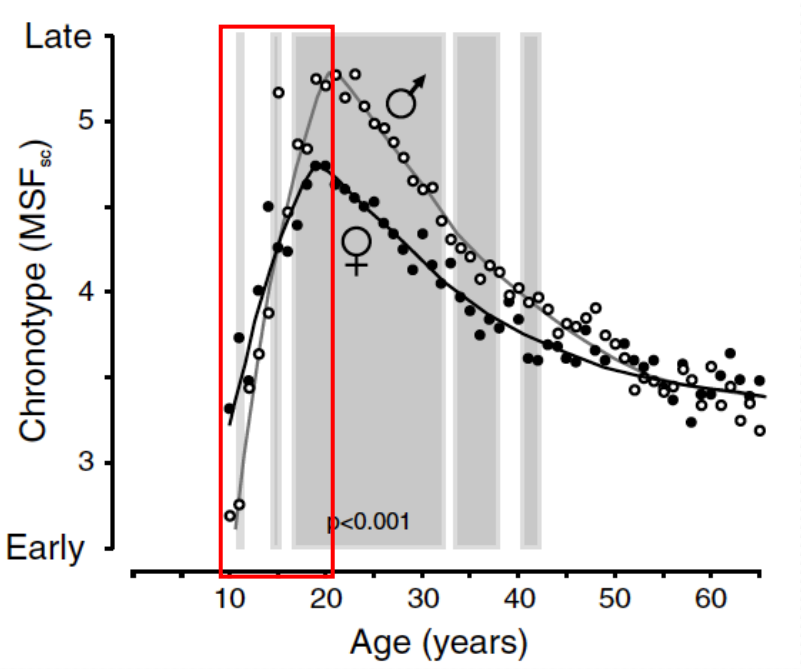
Circadian Timing System



Sleep pressure oscillates daily (circadian)

From: Borbély AA. Human Frontier Science Program, 2000.

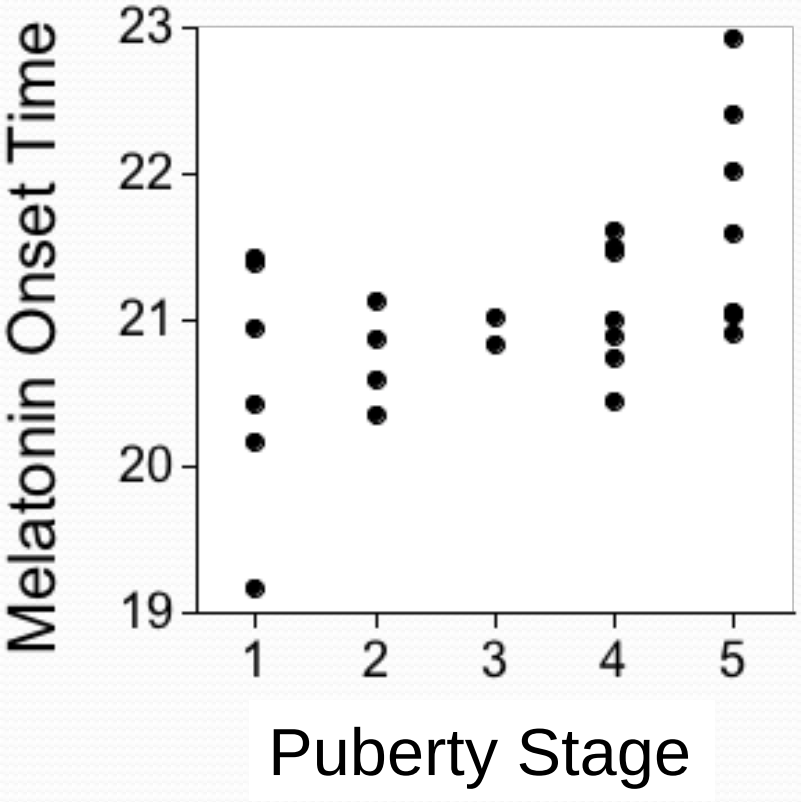
Chronotype and Adolescence



- Time of weekend midsleep
- 2nd decade = marked delay

Roenneberg et al., *Current Biol.*, 2004

Melatonin Phase and Puberty



- Melatonin = 'hormone of darkness'
- Melatonin = start of brain's nighttime
- Adolescence = later timing of melatonin onset time

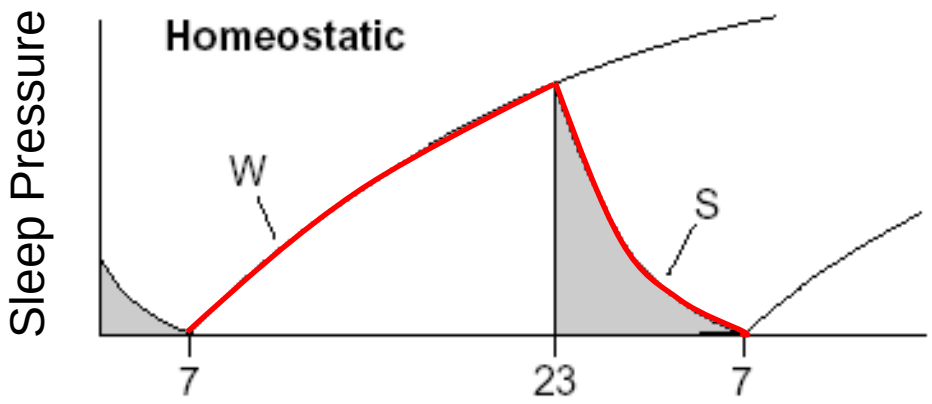
Carskadon et al. *NYAS*, 2004

Circadian Rhythms Summary

- Timing gets later across adolescence
  - Chronotype is later
  - Melatonin phase is later

- Result: late night sleep is favored (so, too, late morning rise)

Sleep-Wake System



Sleep pressure rises when awake

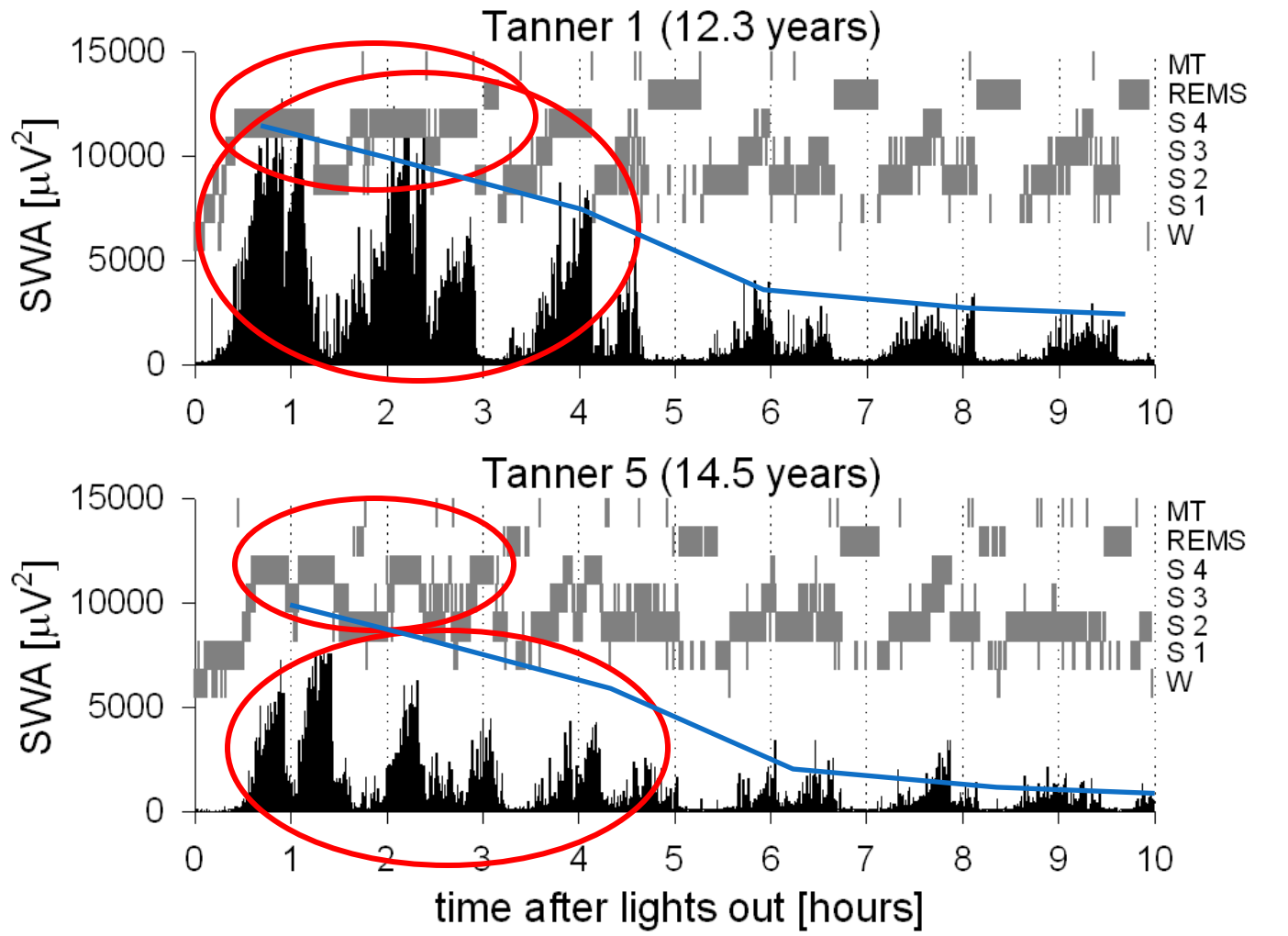
Sleep pressure falls when asleep

From: Borbély AA. Human Frontier Science Program, 2000.

Measures of Sleep Pressure

- Slow wave (NREM stages 3+4) sleep [qualitative: deep sleep]
- Slow-wave activity (SWA) in sleep [quantitative: slow EEG waves]

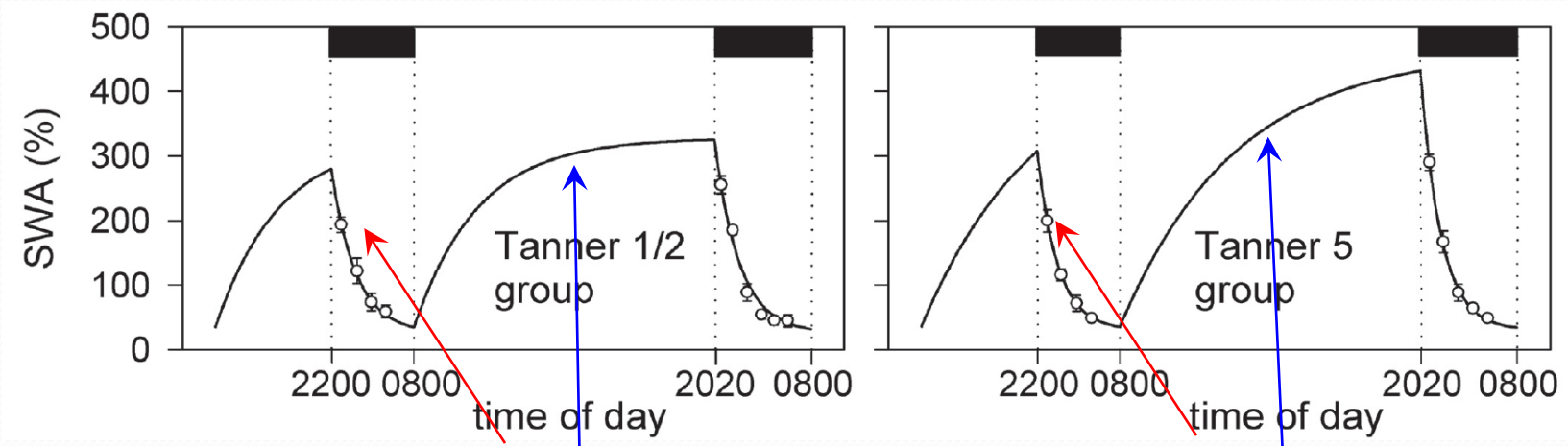
Changes of Slow Wave Sleep and EEG Slow Waves (SWA)



Jenni & Carskadon, *Sleep,* 2004

Across puberty, SWA recovery is unchanged, but *accumulation* rate slows

Tanner Stages 1/2 | Tanner Stage 5



t_d = 2.8 h Decay Time Constant t_d = 2.7 h

t_i = 8.9 h Rise Time Constant t_i = 12.1 h

Jenni, Achermann & Carskadon *Sleep*, 2005

Summary of Sleep Pressure Change

- Recovery sleep process does not change across adolescence
  - Need for sleep is stable
- Accumulation of sleep pressure slows
  - Staying awake longer is a bit easier

- Result: late nights are easier to achieve, but the same amount of sleep is needed

Teen behavior and sleep

- Psychosocial context
- School start time

Psychosocial Context

- Exertion/establishment of autonomy
- Employment
- Substances [no child needs caffeine]
- ‘Screen time’ at night
- Social networking at night
- New loves and loves lost
- …and much much more…
- School schedule

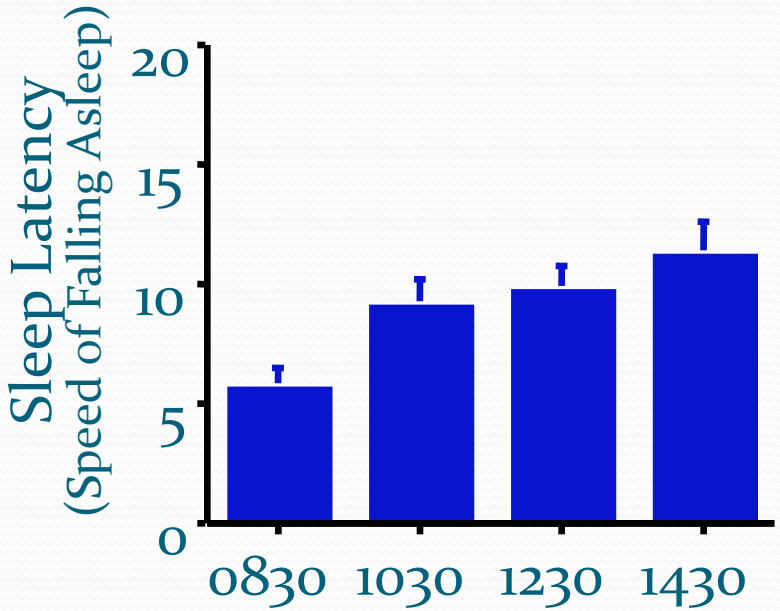
School Start Time (SST)

Schools start early in the US

- Middle school (grades 6-8)
  - 2001 National Household Education Survey
  - ~50% before 8:00 am
  - <25% after 8:30 am
- High school (grades 9-12)
  - 2005 US: >50% start before 8:00 am
  - 2005 Kansas: 2/3 start before 8:00 am; 99% start at 8:30 am or earlier
  - 2010-11 NYC: 10% at 7:30 am or before; 80% at 8:30 or before

Sleepiness in high school students

- 10th graders
- Start time = 0720
- Sleeping about 7 hours a night

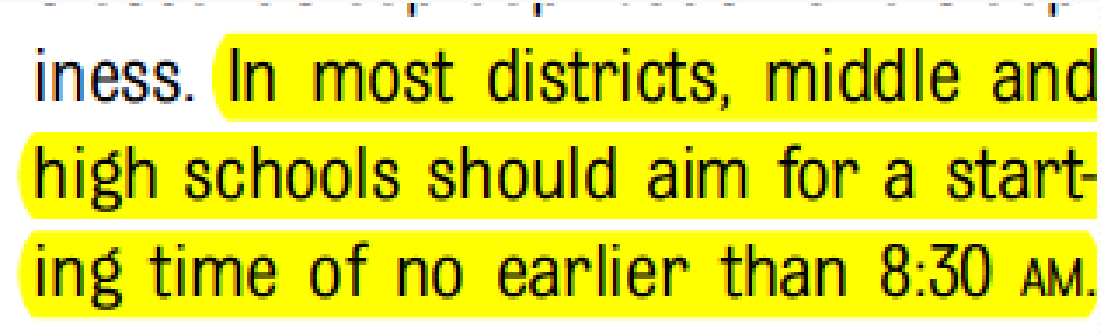


Carskadon et al. *Sleep*, 1998

American Academy of Pediatrics

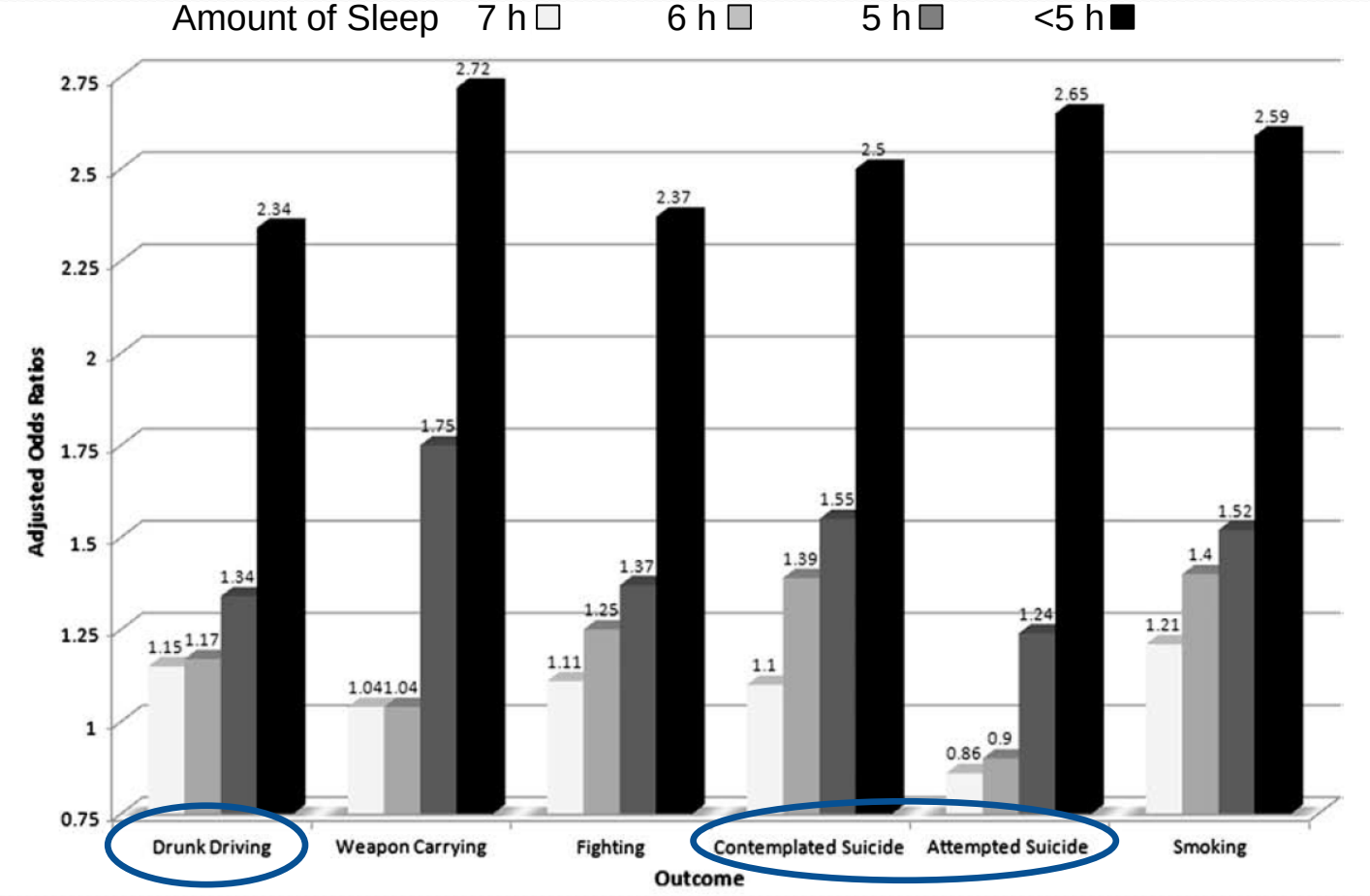
August 25, 2014

American Academy of Pediatrics



iness. In most districts, middle and high schools should aim for a starting time of no earlier than 8:30 AM.

Sleep loss consequences: US Teens



Meldrum & Restivo, *Prevent Med, 2014*

Sleep loss consequences: US Teens

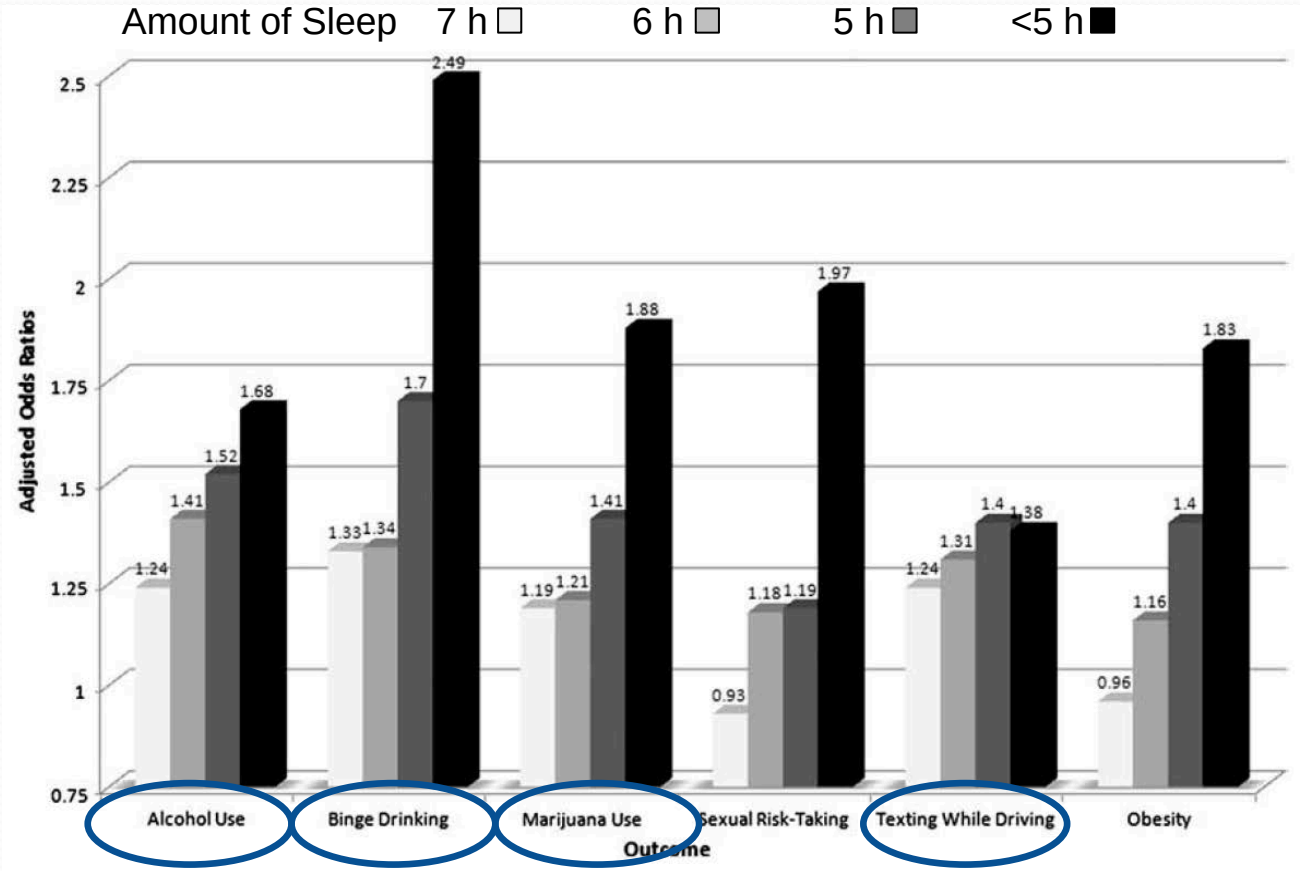


Fig. 1. Adjusted likelihood of behavioral and heath outcomes by sleep status – relative to sleeping 8+ hours, 2011 U.S. YRBS.

Meldrum & Restivo, *Prevent Med, 2014*

Teen crashes and sleep

- Impact of school start time

Teen crashes and school bells

- Lexington, KY [Danner & Phillips, Sleep Med, 2008]
  - From 0800-0900 in Lexington school district
  - Lexington county teen crash rate **down 16.5%**; rest of KY rate **up 7.8%**
- Two SE Virginia towns [Vorona et al., *Clin Slp Med,* 2011]
  - Virginia Beach: SST = 0725; teen crash rate = 65.8/1000
  - Chesapeake: SST = 0840-5; teen crash rate = 46.6/1000

Teen crashes and school bells

District	Time 1 SST	Time 2 SST	Time 1 Crashes	Time 2 Crashes	Percent Change
S. Washington County, MN	0735	0835	144	135	-6%
St. Louis Park, MN	0750	0820	56	61	+9%
Mahtomedi, MN	0730	0800	17	6	-65%
Teton County, WY	0735	0855	23	7	-70%

Wahlstrom, CDC Final Report, February, 2014

Summary

- Many teens don't get enough sleep
- Many teens are fatigued in the early morning, after school, and late at night
- Adolescent short sleep and fatigue have many consequences
- Effects of adolescent insufficient and ill-timed sleep can influence their driving safety

Thank you