

Sleep, Health and School Start Times

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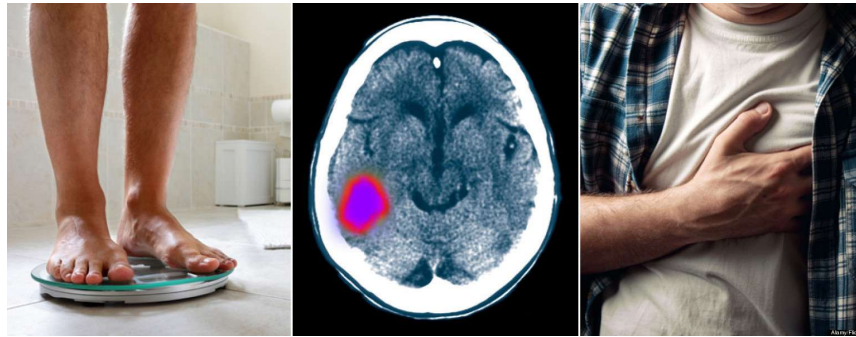
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Objectives

- Outline the neurocognitive, health and safety consequences of deficient sleep in adolescents
- Summarize the evidence supporting healthy school start times as a public health intervention

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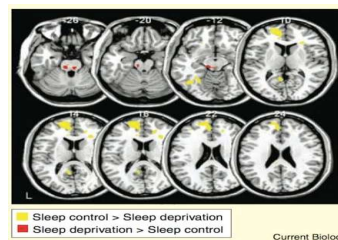
Effects of Deficient Sleep on Health, Safety and Performance



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Contributors to Health Risk Behaviors

- Multiple cross-sectional as well as longitudinal prospective studies link deficient sleep and risk behaviors
- Executive function deficits (pre-frontal cortex)
 - Impaired decision making
 - Reduced motivation
 - Poor judgement
 - Poor impulse control
 - Inattention
 - Poor inhibitory control
- Emotional dysregulation (amygdala)
- Impaired reward-related decision making (striatum)
 - Take more risks due to perception of reduced consequences



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Sleep-Starved?

- 20.6% of adolescents 12-19yo are obese (2015-16; CDC)
- Both cross-sectional and prospective longitudinal observational studies have linked shorter sleep duration with increased obesity risk in children and adolescents (>2x) in a dose-dependent fashion
 - Evening chronotype also associated with increased obesity risk
 - Decreased sleep efficiency (TST/TIB) and regularity also risk factors
- Mechanisms:
 - Appetite regulation (gherlin, leptin)
 - Insulin resistance
 - Food intake: increased amount, more calories, more fat and carbohydrates
 - Eating patterns
 - Physical activity/sedentary behavior
 - Bedtime and sleep routines
 - Sleepiness-related impairments

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Metabolic and Cardiovascular Health

- Short sleep duration associated with increased cardiometabolic risk
 - Insulin resistance, type II diabetes, dyslipidemia, hypertension
- Eveningness chronotype/circadian misalignment associated with Type II diabetes risk (adults)
- Both deficient sleep and obesity have direct detrimental impact on cardiovascular health, metabolic function and systemic inflammation
- Complex interactions with racial and SES disparities

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Immune Function

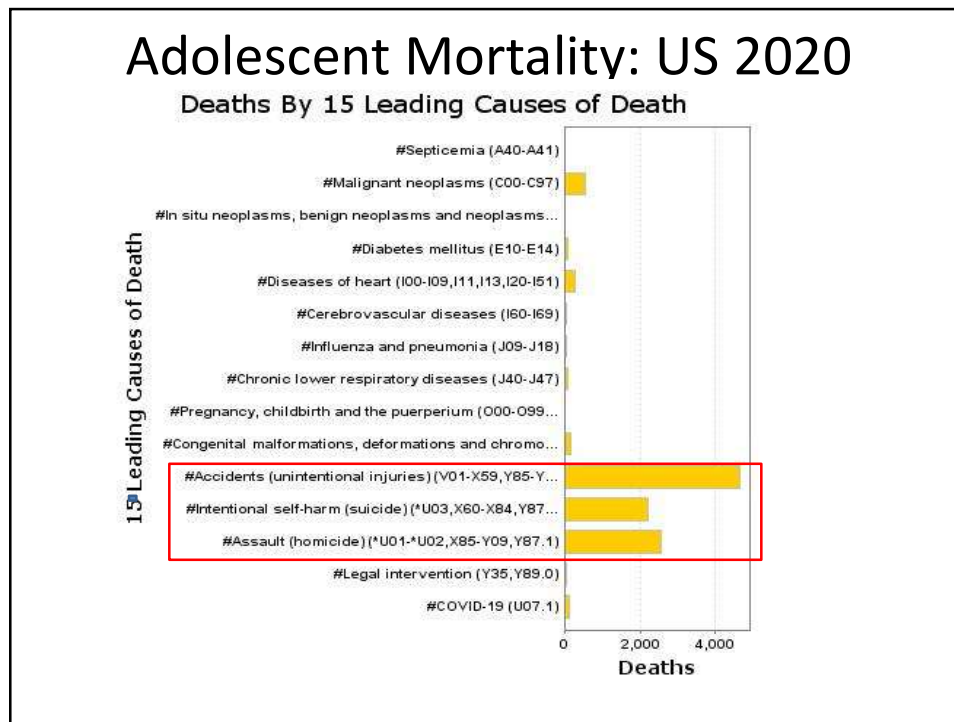
- Immune function
 - Complex bidirectional relationship between sleep and immune response mediators (inflammatory markers):
 - Short sleep associated with susceptibility to and slowed recovery from infection
 - Shorter TST in adolescents associated with increased frequency of common infectious diseases (2014)
 - Short sleep duration associated with poorer antibody response to vaccines (eg, influenza, Hep B)
 - Chronic systemic low-grade inflammation resulting from prolonged sleep deficiency associated with various diseases that have an inflammatory component, like diabetes, atherosclerosis, and neurodegeneration

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Sleep and Medical Conditions

- Recovery from acute injury
 - Mild traumatic injury/concussions (mTBI) are associated with sleep disturbances that can precede, exacerbate, or perpetuate many of the other common sequelae of mTBI, including depression, PTSD, and chronic pain and impair rehabilitation
- Pain
 - Bidirectional relationship: short sleep associated with increased pain perception, intensity; decreased threshold, tolerance
 - Chronic pain conditions (fibromyalgia, JRA, migraines, sickle cell disease)
 - Sleep impacts pain flares/exacerbations, intensity, functional disability

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Safety Issues: Drowsy Driving and MVAs

- Two-thirds of accidental injury fatalities in adolescents are related to road crashes (CDC 2012)
- AAA study (2015) found that 16.3% of 16-18 year olds reported driving while “so tired you had a hard time keeping your eyes open” at least once in the past 30 days¹
- 48% of adolescent drivers reported drowsy driving; every hour less sleep on school-nights compared to a sleep duration of ≥ 8 hrs was associated with an increased risk of drowsy driving²

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Safety Issues: Risk Behaviors

- Survey of >50,000 US high school students: injury risk behaviors significantly more frequent in students sleeping < 7 vs 9hrs¹
 - Infrequent bicycle helmet use
 - Infrequent seatbelt use
 - Texting while driving
 - Rode with drinking driver
 - Drinking and driving (increased 8 vs 9 hrs)

¹CDC MMWR 4/8/16

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Safety Issues: Risk Behaviors

- Sleep loss also associated with:
 - An increased risk of pedestrian injuries in children (2014) and more risk-taking behaviors crossing streets in adolescents (2013)
 - Increased sports-related and musculoskeletal injuries in adolescents (2014)
 - Increased training time associated with less sleep (2019)
 - An almost 3x risk in adolescents of work-related injury requiring medical care (2015)
 - 2-5x risk of in-school/out of school repeated injuries (2015)

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Depression Symptoms and Suicidal Behavior

- Chronic sleep loss associated with depressive symptoms in adolescents
 - In a sample of HS students (N>10K), 38% overall with insufficient sleep; 40% of teens getting 6 or less hours of sleep reported depression symptoms (sadness, hopelessness)
 - Insufficient sleep associated with increasing trends in suicidal ideation and behaviors in adolescents (N=73K), especially among female, older and Black adolescents (2007-19)
- Circadian rhythm disturbances and evening chronotype associated with depressive symptoms in adolescents
- Studies suggest that interventions targeting improved alignment between circadian biology and sleep-wake behavior are a potential mechanism in the relationship between sleep and depression symptom improvement

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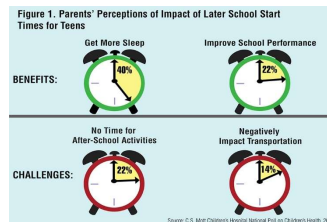
Substance/Alcohol Use

- Systematic review (2019):
 - Positive associations reported in adolescents between all substances used and sleep disturbances in sleep health domains of Regularity, Timing, Efficiency, and Duration
 - Alertness problems were also positively associated with tobacco and alcohol use
 - The most common disturbance reported was the insufficient sleep Duration
- YRBS study (2015)
 - HS students: average WD sleep duration 6.5 hrs; 77% reported <7hrs sleep; 20% < 5 hrs
 - 37% of those getting 7 hrs of sleep reported tobacco/alcohol/marijuana use (vs 14% with 9 hrs)
 - Almost 3 times as many students getting less than 6 hours of sleep report alcohol use in the past 30 days compared to those getting 9+ hours

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What is the Role of School Start Times?



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What We Know

- The most recent meta-analysis (2022) of the impact of SSTC largely included self-reports (n = 18), actigraphy or a combination of self-reports and actigraphy (n = 5)
 - Assessment of sleep variables: increased sleep duration, later rise times, less weekend oversleep, decreased daytime sleepiness, improved sleep satisfaction
- Changes in SSTs to between 8:30a and 8:59a are associated with better outcomes than 8:00a to 8:29a start times
 - However, more studies with SSTs before 7:30a have implemented new SSTs between 8a and 8:29a vs 8:30a+
- In 2017–2018 less than 18% of US schools started at or after 8:30 a with most U.S. schools starting at 8 a on average, and 42% of schools starting earlier

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Associated Outcome Measures

- **Academic performance:**
 - Associations between later school start times and academic performance may be mediated by reduced sleepiness and improved attention during the school day particularly among high school students
 - However, the evidence concerning the impact of later school start times on grades and standardized test scores is mixed
 - But a number of studies have shown that later school start times are associated with improvements in attendance among 9th through 12th graders and graduation rates
- **Mental Health:**
 - Overall, studies show that later school start times predict better mental health including less negative mood, and fewer symptoms of anxiety and depression among adolescents
- **Health and Safety Outcomes:**
 - Decreased caffeine use
 - Decreased use of school health services
 - Reduced rates of drowsy driving and car crashes: significant reduction in adolescent car crashes in districts with later vs earlier SSTs and in schools post- compared to pre-SST delay

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Middle School SSTs

- **Narrative review 2002-2020**
 - The methods included experimental with control group, prospective, longitudinal within-participants, cross-sectional between-participants, and retrospective case-controls
 - Amount of time instituted for the delay ranged from 20 minutes to 45 minutes with the latest delay being to 9:00a, followed by 8:15a and 8:00a
 - Students obtained ≥ 8 hours of recommended sleep when middle schools started at $\geq 8:30a$
 - When SST shifts were to $\leq 8:30a$ there was less improvement in TST
 - Cross-sectional comparisons found that students attending later-starting schools had more TST than students attending earlier-starting schools
 - Middle schools that started before 8:00 AM were associated with more daytime sleepiness

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Middle School SST

- Middle schools that instituted a delay in SST to at least 8:30a observed improvements in tardiness (decreased 3-5x) and absences
- Less negative affect and mood, self reported depressive symptoms and anxiety, lower perceived stress, and less engagement in behavioral and verbal aggressive actions
- Late middle school start times can improve adolescents' sleep and reduce daytime sleepiness by increasing total sleep time and delaying waketime.
- Some studies show improved grade-point average in core subjects, and standardized test scores
- Overall, early middle school start times are associated with worse sleep, behavioral health, and academic performance outcomes
- However, while benefits may be associated with even small delays (e.g., 20 min to 8:15a), two longitudinal studies that implemented a delay earlier than 8:30 AM found small non-significant gains

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Additional Benefits

- Single district: MS ST moved later by 40-60 min; HS 70 min; ES moved 60 min earlier
- Pre-post parental sleep
 - Later wake times, sufficient SD; good sleep quality; HS parents less tired ($p < .0001$)
 - Minimal impact sleep of ES parents
- Pre-post teacher sleep
 - Later rise time (28 min); increased SD 22 min; improved daytime functioning
 - ES teachers earlier bed and wake times (9 min) with no change SD or daytime functioning

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Scoping review SST 2015-23

- MN: Longitudinal cohort study: reduction in daytime sleepiness, tardiness and absences in SST change schools (50-65 min delay from 7:30-7:45a)
 - Fewer behavioral referrals; slightly higher GPA; larger and more effects 2nd year after delay
 - No significant differences BMI but modestly better healthy eating (eat breakfast, less fast food, more active)
- Seattle: pre-/post-study: increase in the daily median sleep duration of 34 min, 4.5% increase in the median grades of the students, improvement in attendance (delay 7:50-8:45a)
- Public HSs in 7 states: graduation/attendance rates increased (80% 90%; 90-93%) 4 years after >8:30a, including SES and racially disadvantaged

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Scoping review SST 2015-23

- Denver: 2 yr longitudinal study SST change (ES – 60 min; MS + 40-60; HS +70 min, no change ES sleep duration/quality/sleepiness across all demographics
 - Parents reported longer sleep duration/better quality/less fatigue
 - Teachers reported later rise time (28 min); increased SD 22 min; improved daytime functioning
- VA: Less low mood, drowsy driving, skipping breakfast (50 min delay to 8:10a)
- Cross –sectional internet survey: lower migraine frequency in students with SST $\geq$ 8:30 vs <8:30; 60 min difference sleep duration

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The Impact of the Pandemic

- Virtual learning schedules during the pandemic:
 - Sleep schedules (Bedtime/Wake time) shift later
 - However, almost all studies report increased sleep duration as a result of later wake times
 - Many studies demonstrate less daytime sleepiness
 - Regularity of sleep patterns (“social jetlag”) improves
 - Evidence supports later school start times

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Thank you!
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