



Later School Start Times as a Public Health Intervention to Promote Sleep Health in Adolescents

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Abstract

Purpose of Review Poor sleep health in adolescence has long-lasting, and adverse effects on many aspects of health and functioning. Multiple factors impact sleep in adolescence including individual and family-level factors. However, early school start times are the one policy-level, and possibly the most salient environmental factor that constrains adolescent sleep at a population level.

Recent Findings Delaying school start times could be an effective strategy to promote sleep health and consequently, functioning, and physical and mental health among adolescents. Growing evidence suggests that adolescents at later-starting schools sleep longer on weekdays, have higher attendance and graduation rates, and fewer mental health symptoms compared to their peers at earlier-starting schools.

Summary This paper reviews a summary of recent key findings and discusses future steps in translating the school start time research into policy.

Keywords Adolescent sleep · School start times · Public policy · Adolescent health · Sleep health

Introduction: Sleep During Adolescence

Adolescence is a highly sensitive developmental period characterized by dramatic neurobiological, physical, and socioemotional changes. These changes have direct implications for adolescents' sleep-wake patterns [1]. In fact, there is a significant increase in poor sleep health symptoms during the adolescent developmental period [2]. For example, current recommendations suggest that adolescents require 8–10 h of sleep to function optimally [3, 4]. However, the vast majority of adolescents fall far short of these recommendations, with national data showing that 70% of adolescents obtain less than 7 h of sleep on school nights [5, 6]. Additionally, there are sleep disparities among adolescents, with girls, non-Whites, and those from lower socioeconomic status (SES)

backgrounds, being more likely to report short sleep duration compared to other groups [7, 8]. For example, increasing evidence suggests that Black adolescents obtain less sleep and more fragmented sleep and report poorer sleep quality compared to their non-Black peers [9–11]. Additionally, compared to adolescents from higher SES backgrounds, adolescents from lower SES backgrounds are at increased risk of shorter sleep duration and more irregular sleep patterns [12].

Nationally, despite increased public attention focused on the importance of healthy sleep, data suggests that the proportion of high school students obtaining the minimum recommendation of 8 h of sleep per night (a specific objective of Healthy People 2030) has steadily declined [7, 13]. Beyond insufficient sleep duration, adolescents are also at high risk for a host of other sleep health problems, including irregular sleep-wake patterns, daytime sleepiness, and clinically significant poor sleep quality [2, 14].

In this paper, we aim to summarize the evidence concerning the importance of sleep during adolescence, impacts of sleep on adolescent wellbeing, factors influencing sleep among adolescents, and impact of later school start times as an effective population-level strategy to address key domains of adolescent functioning as well as broader economic implications. We conclude by reviewing the implementation

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considerations that communities must address when delaying school start times and future directions in translating the school start time research into policy.

Adolescence Is an Inflection Point for Health Risk Trajectories

Despite being at a peak stage of health in terms of cognitive health and physical robustness, adolescence is a highly vulnerable period for increased morbidity and mortality [15–17], a conundrum termed as the “adolescent health paradox” [18, 19]. In fact, the origins of major chronic mental and physical illnesses, including depression, substance use, obesity, cardiovascular disease, and diabetes emerge in adolescence. [20, 21]. For example, mental health issues increase dramatically during adolescence, with 50% of all lifetime depression onset occurring by age 14 [22]. Adolescence is also an inflection point for the initiation and escalation of substance use and disorders [23] and is a critical period for the development of lifestyle behaviors, including sleep patterns and behaviors, that can set the stage for health risk trajectories into adulthood. Therefore, adolescence is a vulnerable developmental period and a key opportunity to leverage multi-level, evidence-based interventions to promote both immediate and long-term health outcomes.

Sleep Impacts Multiple Domains of Adolescent Health and Functioning

Sleep plays a vital role in the health of adolescents and is directly linked with optimal functioning, including better academic achievement [24–27] and physical and mental health [28–31]. In contrast, developing sleep problems such as chronic insufficient sleep in adolescence has cumulative, long-lasting, and adverse consequences [18] and accounts for an increased risk of mental and physical problems later in life such as depression, substance use disorder, obesity, and cardiovascular disease [32–37]. However, adolescent sleep problems extend beyond insufficient sleep. For example, insomnia and social jetlag, which refers to large discrepancies in weekend/weekday sleep timing [38] or irregular sleep schedules, are highly common among adolescents [39], and are also associated with adverse mental and physical health outcomes [39–43].

Given robust, longitudinal associations between various indicators of poor sleep health and increased risk for a host of negative sequelae, including mental health disorders [44, 45], suicide [46], substance use problems and disorders [47, 48], chronic diseases [49, 50], and impairments in social and academic functioning [24, 51–53], there is an urgent need to

identify evidence-based strategies to address the population-level health crisis among adolescents.

Factors Influencing Adolescent Sleep

Biological, social, and environmental factors independently and collectively influence adolescents’ sleep patterns. Developmentally specific changes in the two biological processes known to regulate sleep, circadian timing, and homeostatic sleep pressure or sleep drive [54, 55] contribute to a delay in the timing of sleep among adolescents. More specifically, the release of melatonin at night is delayed during adolescence resulting in a biologically driven phase delay (i.e., the tendency for adolescents to naturally prefer later bedtimes and later wake-up times). Furthermore, in contrast to children and younger adolescents, older adolescents have a slower build-up of homeostatic sleep pressure, which allows them to delay bedtimes. In addition to the biological factors that push adolescents toward delay in the timing of circadian rhythms (i.e., later bedtimes and delayed waketimes), various social factors may put excessive demands on adolescents’ time and hinder obtaining sufficient sleep [56–59]. These factors include late evening light exposure, increased social opportunities, academic responsibilities, extracurricular activities, and after-school employment.

Considering the high prevalence of insufficient sleep among adolescents in general and robust associations between chronic sleep insufficiency or poor sleep health more broadly and adverse physical and mental health outcomes, it is important to consider strategies and interventions to address short sleep among adolescents at the population-level. Specifically, early school start times have been identified as the one policy-level factor, and possibly the most salient environmental factor that constrains adolescent sleep at a population level (e.g., [60, 61]). Early school start times during the academic year are in direct conflict with the biologically driven circadian shift towards later bedtimes and later wake-up times among adolescents, directly constraining their opportunity for sufficient sleep duration [3, 4]. In essence, early school start times pit adolescents and their families in a fundamentally unwinnable fight against their own sleep-wake biology—a conflict termed as “the perfect storm” [54, 55, 62]. In turn, later school start times could be the most effective population-level intervention to achieve longer sleep duration and promote physical and mental health in adolescence and may be an important step towards mitigating sleep health disparities among socioeconomically disadvantaged or minoritized racial/ethnic adolescent groups. Consistent with these claims and with robust evidence supporting the benefits of later school start times for adolescent health and functioning, major medical

organizations including the Centers for Disease Control and Prevention (CDC) [63], the American Academy of Pediatrics (AAP) [64], and the American Academy of Sleep Medicine (AASM) [65, 66] have recommended that middle and high schools start no earlier than 8:30 am.

Summary of the Evidence Concerning the Intersection Between School Start Times and Adolescent Sleep and Key Outcomes in the USA

The recommendations from major medical organizations and the pioneering work on the benefits of later school start times for adolescents date back to the 1990s with Dr. Kyla Wahlstrom's landmark research in Minnesota school districts. However, according to recent federal data (2017–2018) [67], less than 18% of US schools start at or after 8:30 a.m. with most U.S. schools starting at 8 a.m. on average, and 42% of schools starting even earlier. In this section, we will provide a summary of the evidence concerning the impact of later school start times on key domains of adolescent functioning, including sleep, academic performance, health and safety, and economic implications. Several prior reviews and meta-analyses have been recently published on this topic [61, 68, 69], so this is intended as a summary of recent key findings, rather than a systematic review.

Later School Start Times and Sleep

Later school start times are consistently associated with longer sleep durations on school-nights, primarily due to shifting rise times later [68, 70–74, 75•, 76, 77•, 78•], and decreased catch-up sleep time on weekends and greater regularity in sleep schedules [71, 75•]. Indeed, a 25–30-min delay in school start time is associated with a 29–45-min increase in average sleep duration on school nights [75•, 76, 79–81]. A recent longitudinal study by Widome and colleagues [75•] is one of the most compelling studies examining the association between later school start times and sleep duration. This 2-year natural experiment used wrist actigraphy to measure objective sleep outcomes and was conducted among 455 students from 5 Minneapolis-area high schools, 2 of which delayed their start times by 50 to 65 min. Adolescents attending the schools with later start times had a 40-min longer sleep duration over the course of 2 years compared to their peers in the 3 comparison schools that did not change school start times. Contrary to the common misconception that later school start times will simply cause adolescents to stay up later at night resulting in no significant net changes in sleep duration, adolescents attending schools with later start times did not go to bed later and this is also consistent with previous studies [82]. Furthermore, Widome

and colleagues found that delaying high school start times may not only increase adolescent school night sleep duration but also decrease catch-up sleep time on weekends [75•]. Another recent large-scale, longitudinal study that included a diverse sample (55% White, 10.4% Black, 17.5% Hispanic, 8.1% Asian, and 9% Other) was conducted before and for 2 years after school start time changes and found significant increases in sleep duration among secondary school students after school start time change with benefits maintained over the 2-year follow-up with benefits of later school start times similar across racial groups [78•].

Later school start times may also confer some benefits for reduced daytime sleepiness. Indeed, a review of school start time studies by Wheaton et al. found less reported daytime sleepiness or falling asleep in class in schools with later start times in 10 out of 12 reviewed studies [68]. Recently, Meltzer and colleagues also found a notable decrease in the percentage of students reporting clinically significant daytime sleepiness among both middle (from 48.7 to 37.1% students) and high school students (from 76.2 to 55.2% students) after transitioning to later school start time in Colorado [78•].

The natural experiment caused by the closure of schools due to the coronavirus disease 2019 (COVID-19) lends further evidence to support the contention that removing or eliminating scheduling constraints by delaying school start times could be an effective solution for extending sleep. Indeed, school closures and the transition to remote learning during COVID-19 greatly impacted sleep among adolescents (e.g., [83–85]), leading to significant increases in adolescent sleep duration [83]. For instance, a longitudinal study examining changes in sleep before and during the early months of the pandemic among urban American Indian/Alaska Native (AI/AN) showed that adolescents' sleep duration increased by 130 min on average during weekdays during COVID-19 [84]. These findings support previous studies suggesting that later school start times may be an effective strategy for extending sleep among adolescents.

Later School Start Times and Academic Performance

From a mechanistic perspective, there is clear and conclusive evidence that indicators of poor sleep health, including insufficient sleep and irregular sleep schedules, are associated with lower attendance at school, lower likelihood of graduating high school or college, and poorer academic performance among adolescents [25, 30, 86, 87]. The associations between later school start times and academic performance may be mediated by reduced sleepiness [68, 70, 73, 76, 77•, 78•, 79, 80] and improved attention during the school day [88], particularly among high school students [76]. However, the evidence concerning the impact of later school start times on grades and standardized test scores is mixed with some studies showing a positive impact [82,

89] and others showing a null effect [90, 91]. Such mixed results may reflect the fact that many factors contribute to such outcomes, and among the highest performing students, there may be little room for improvement even with a later school start time, resulting in limited variability and overall null effects.

In contrast, when considering the impact of later school start times on other indicators of academic performance, the results are more consistent. For example, studies have shown that later school start times are associated with improvements in attendance among 9th through 12th graders [92–94], and graduation rates [93]. Attending school is crucial for academic performance and the largest gains in school attendance due to later school start times may be observed in schools with more economically disadvantaged students and ethnic minorities. In a pre-/post-study of sophomores of two public high schools in Seattle (WA) School District, Dunster and colleagues found that tardiness and absenteeism significantly decreased after changing school start times from 7:50 to 8:45 a.m., but only in the school with more economically disadvantaged students (88% vs. 31%) and ethnic minorities (68% vs. 7%) [77•]. This finding highlights the importance of delaying school start times as an important strategy in decreasing the opportunity gap for socioeconomically disadvantaged youth and those from minoritized racial/ethnic groups, including African American, Hispanic, and American Indian/Alaska Native youth.

Later School Start Times and Mental, Physical Health, and Safety

Despite the robust association between poor sleep health and mental health among adolescents [43, 95–98], the literature examining the effects of later school start times on adolescents' mental health is scant and limited to studies assessing symptoms of anxiety and depression [60, 61]. Overall, these studies show that later school start times predict better mental health including less negative mood [76], and fewer symptoms of anxiety and depression among adolescents [60, 79, 80, 94]. Yet, the impact of school start times on other aspects of mental health and adolescents' functioning such as risk-taking behaviors warrants further research. As mentioned elsewhere [69•, 73], an ongoing assessment of both short- and long-term effects of school start time changes on adolescent sleep and functioning is a critical next step.

Poor sleep health is also associated with physical health outcomes such as obesity, as well as adolescents' physical safety [99–103]. A shift to a later high school start time has the potential to positively impact physical health outcomes such as obesity among adolescents. A few studies have attempted to examine the association between later start times and obesity [104, 105] and the preliminary findings show better dietary quality and more healthful weight

behaviors of students attending delayed-start schools compared to their peers [68, 105, 106]. Several studies have also examined the effect of later start times on car crash and unintentional injury rates among adolescents and found that delayed start times and receiving more sleep as a result may lead to fewer car crash rates and unintentional injury [68, 107], most likely through reduced sleepiness [68, 70, 73, 76, 77•, 78•, 79, 80].

Later school start times also have the potential to positively impact other members in the family. For example, a recent study showed that parents' sleep-wake patterns also changed with the implementation of later middle and high school start times [108]. Specifically, later school start times were associated with greater number of parents obtaining sufficient sleep, as well as greater sleep quality of parents of adolescents.

Later School Start Times and Economic Implications

Later start times not only positively contributes to adolescents' health, functioning, and safety but may also have implications for the economy by improving academic performance and reducing car crash rates and injuries [109•]. Using a novel macroeconomic modeling approach, the RAND Corporation comprehensively examined the potential economic implications of later school start times, projecting that a state-wide shift in school start times to 8:30 a.m. or later across the USA would result in an \$8.6 billion boost to the US economy over a 2-year period, and an \$83 billion gain over a 10-year period [109•]. In fact, even when estimating higher potential cost projections of such a policy shift (e.g., shifting bus schedules, adding lighting for athletic fields), the economic models suggested that most states would reach the “break-even” point within a 2-year policy horizon, meaning that for every dollar spent, there would be a dollar return on investment. The economic benefits modeled in this study focused specifically on the potential benefits to the economy derived from a reduction in car crashes and improvements in graduation rates observed among teens who are given adequate opportunity to sleep. This study is promising in that proposed changes in school start times are often met with resistance given concerns about the economic costs of such changes. However, such concerns neglect to consider the potential economic, not to mention, public health benefits of increasing sleep opportunity among adolescents.

Implementation Challenges Related to Changing School Start Times

Although every school district faces unique challenges when considering a policy shift towards later school start times, resistance to school start time change is largely centered on logistical challenges associated with different

aspects of community life, including concerns about bus-sing, extracurricular activities, childcare for younger siblings, student jobs, and impacts of scheduling changes on the broader community, including traffic patterns and safety [110]. Yet, experiences from schools that have delayed start times have shown that it is possible to work through these expected challenges [111, 112•]. For instance, transportation logistics are one of the key considerations in delaying school start times. Indeed, many districts, due to financial considerations associated with transportation, employ a multi-tiered bus schedule (i.e., staggered bell times) instead of a delivery system (i.e., similar bell times across levels) [110]. A large number of districts with the successful implementation of later school start times have utilized the “flipped busing” model, whereby the secondary/high school and elementary bell schedules are flipped [110, 111, 112•]. Some other strategies to facilitate later school start time for high school students include carpooling, encouraging the use of public transportation, and allowing middle and high school students to share buses [110, 112•]. In fact, in school districts that high school students use public transportation (e.g., public bus system), transportation logistics are less of an issue [113].

To address logistical challenges anticipated by the community, in general, it is crucial to identify implementation characteristics of districts that have successfully delayed school start times and improved sleep time and functioning among adolescents. Yet, the specific implementation plans of each district will differ depending on the communities they serve. One important strategy is to engage the community early in the decision-making process and not only explain the rationale behind this decision but also prepare to address biases and questions raised by various stakeholders [111, 112•, 114]. As the first step, it is important to identify the concerns and obstacles that may hinder moving to later school start times and generate solutions for such concerns before announcing any changes [111]. Next, the districts may benefit from educating the entire community (e.g., students, parents, fellow administrators, and teachers) and explaining the “why” or the rationale behind later school start times, the benefits of this decision, possible challenges, and finally, solutions to the raised concerns. It is of considerable importance to highlight the benefits of obtaining more sleep for adolescents' academic functioning, safety, and physical and mental health [110, 114] and this has been an important role adopted by many sleep scientists who have embraced the opportunity to work collaboratively with advocacy groups and to educate communities about the intersection between sleep science and school start times [69•, 115]. Indeed, the mandated school start time in California provides ample opportunities to examine strategies to delay school start times. In 2019, California legislators passed a law mandating public high schools begin classes

no earlier than 8:30 a.m., allowing public school districts 3 years to transition to later start times (Bill Text - SB-328 Pupil attendance: school start time. (ca.gov)) and Florida passed a similar law in May of 2023. Other state legislators including New Jersey, New York, Massachusetts, and the Virgin Islands are currently considering mandated school start time changes. An important lesson from the districts that have delayed school start times is that the expected challenges about the impact of this change on transportation, childcare, student jobs, and other scheduling changes on the broader community are worse in anticipation than in reality and are largely addressable with stakeholders' involvement and community education at low or no cost [69•, 110, 116]. For instance, the CaSTLES, a large-scale and longitudinal study conducted among elementary and secondary school students, provides strong evidence that “flipping” elementary and secondary school start times to accommodate transportation schedules is not only a logistically and financially feasible option but also is a significant and effective strategy to improve sleep duration among secondary school students with a minimal impact of earlier start times on elementary school students [78•]. Nevertheless, every community has different sets of needs, concerns, and goals, which highlights the importance of implementation strategies that effectively engage diverse stakeholders throughout the process and that allows sufficient time to work through implementation challenges as well as sufficient time to evaluate the impact of the policy change.

Conclusion

Adolescence is a sensitive and critical period of development [117, 118]. This critical stage of development represents a unique window of opportunity for examining the determinants of health outcomes and establishing science-based strategies that ensure positive long-term health trajectories. Adolescents of today experience unique psychosocial challenges that are associated with increased risk for various adverse physical and mental health outcomes. For example, the COVID-19 pandemic has impacted all segments of the population but the impacts of the pandemic are especially evident among adolescents [119], disrupting their social rhythms and impacting their mental health. Indeed, recent data from the Youth Risk Behavior Survey shows that from 2011 to 2021, the percentages of high school students who experienced persistent feelings of sadness or hopelessness and who seriously considered attempting suicide have increased from 28 to 42% and 16 to 22%, respectively [120].

Sleep plays an important role in the health of adolescents, and poor sleep health during this critical period of development can have long-lasting effects on various domains of health and functioning. Although there has

been a great advancement in understanding the key determinants of sleep health and the role of insufficient sleep in both short-term and long-term mental and physical health outcomes, translating the science into policy and practice in hopes of increasing sleep duration remains a challenge.

Multiple factors contribute to poor sleep among adolescents including individual-level factors such as adolescent's chronotype (sleep-wake preference), use of technology, and family-level factors such as parental monitoring and setting up routines. In fact, limited evidence suggests that adolescents with delayed chronotypes may be even more adversely impacted by early school start times [121]. However, at a population-level, delayed school start times are the one policy-level factor that has been shown to promote adolescent sleep overall. The extant literature is robust in showing support for this policy-level intervention. The findings of studies examining the impacts of later school start times are consistent in showing that adolescents in the later-starting schools obtain more sleep compared to their peers at the earlier-starting schools. Most studies also show clear benefits of later school start times for key indicators of academic performance including attendance and graduation rates, mental and physical health, and the safety of adolescents.

Despite the robust and consistent supporting evidence for later school start times, there are many logistical and implementation challenges that may be perceived by school districts and deter them from implementing such a change. The next crucial step in translating the school start time research into policy is to conduct implementation science research to identify the most effective strategies to address anticipated challenges by school districts and build support for implementing such a change. Furthermore, it is of crucial importance to incorporate multi-level strategies to improve adolescent sleep health, including school start time changes as well as disseminating the evidence-based findings and educating the school districts and policymakers on sleep health and role of sleep in contributing to various aspects of functioning among adolescents. Targeting sleep health with an evidence-based, population-level intervention, such as delaying school start times, is critical to address the crisis of insufficient sleep among adolescents, and to promote adolescent health and academic functioning in an equitable manner.

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Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent N/A

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