THE IMPACT OF SCHOOL START TIMES ON ADOLESCENT HEALTH AND ACADEMIC PERFORMANCE

REVIEW OF LITERATURE ON ADOLESCENT SLEEP & SCHOOL STARTING TIMES

- There has been a general consensus that American adolescents are not getting enough sleep.

- Studies conducted over a nearly 30 year period have consistently shown only a small fraction of adolescents obtain the 9 or more hours of sleep they require to function at their best. While teenagers are notorious for causing their own sleep difficulties – staying up too late, playing with electronic gadgets, and generally burning the candle at both ends – sleep loss among adolescents is confined primarily to school nights.

- Insufficient sleep time could impair adolescents' learning and development.

- Restricted sleep in adolescents is associated with profoundly impaired learning capacity, increased rates of depression, anxiety, and fatigue, increased risk of suicidal ideation and completed suicide, increased rates of automobile accidents, decreased athletic and motor skills, excessive weight gain, increased likelihood of criminal conduct, risk-taking behaviors, including drug or alcohol use, increased likelihood of physical, psychological, or social difficulties, elevated blood pressure, interference with secondary brain development.

- There is evidence that students could benefit from a late school schedule by having more sleep time.

- Most U.S. high schools schedule classes during the 7 o'clock hour, while melatonin still pressures adolescents to sleep. The vast majority of teenagers attending early starting schools meet the morning bell in a sleep-deprived state.

- The National Institutes of Health and the American Lung Association of New England have identified early school start times as a factor contributing to teen sleep deficiency. Janet Croft, Ph.D., a senior epidemiologist at the CDC, believes that early school start times have a "deleterious impact" and impose "an unrealistic burden" on adolescent students.

- In 1994, physicians began advising school leaders to "eliminate early starting hours for teenager(s)". Sleep experts urged a delay in morning classes until 8:30 a.m., or later, for middle and high school students.

- A widely cited study conducted by Wolfson and Carskadon (1998) in which students self-reported high grades were found to have more sleep time then those who self-reported low grades.

- Students at later starting schools get more sleep, perform better academically, have significantly fewer automobile accidents, report greater motivation and less depression, and experience fewer physical health difficulties

- Multiple factors contribute to sleep deficiency in teens, including electronic devices, jobs, erratic sleep schedules, caffeine, social and school obligations. Restricted sleep, however, is primarily limited to school nights, rather than weekend nights, with students losing up to 2 hours of sleep each night after the start of school.

- Physicians from the Thoracic Society of Connecticut assembled a task force to both raise awareness and advocate for a change to later start times. According to Dr. Heidi Connolly, Associate Professor of Psychiatry and Pediatric Sleep Medicine at the University of Rochester Medical Center in New York, “Sleep medicine specialists have long known that delaying high school start times helps teenagers sleep better.”

- In 2009, a Rhode Island high school changed start times from 8 a.m. to 8:30 a.m. at the urging of sleep medicine specialist, Dr. Judith Owens. As in Minnesota, fewer depressive symptoms were reported among students following the change. Researchers found this “particularly noteworthy given the relationship between depression and suicidal ideation in adolescents. In addition, students reported feeling more motivated to participate in a variety of activities and were less likely to seek medical attention for fatigue-related concerns. Following the change, students actually went to bed 15 minutes earlier, increasing their nightly sleep total by 45 minutes.”

- There is an economic benefit. Considering this and other evidence, including a seven-year middle school study by Finley Edwards, Ph.D., Brookings Institute economists “conservatively” estimate that when middle and high school start times are delayed “from roughly 8 a.m. to 9 a.m.” student achievement will increase by 0.175 standard deviations, with a corresponding increase in student future earnings of approximately $17,500 lifetime, at little or no costs to schools; i.e., a 9 to 1 benefits to costs ratio.

- Scientists in Kentucky and Virginia found significantly decreased frequencies of automobile crashes among teens in districts where start times were pushed back an hour or more to 8:30a.m., or later – a significant finding when one considers automobile accidents account for more than one-third of all teen fatalities.

- Careful planning is required in order to successfully delay start times. Adults may be inconvenienced for the benefit of students. Budgets, busing, and polities determine school schedules more often than students’ best interests. Stakeholders often contend delaying school schedules will disrupt sports, jobs, extracurricular activities, and daycare plans.

- Professor of Neurology and Director of the Minnesota Regional Sleep Disorders Center, Dr. Mark Mahowald, notes “Not a single excuse we’ve heard relates to education. None of the excuses have the word ‘education’ in them. We should send kids to high school in a condition that promotes learning rather interfering with it.”

- A point of concern raised by the Center for Disease Control (CDC) and the National Institutes of Health is that the ultimate decision for determining start times will substantially be determined by the whims of local school boards.

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THE BASICS OF ADOLESCENT SLEEP BIOLOGY AND RELATED RESEARCH

- The great majority of high school students are getting insufficient sleep. The 2011 Centers for Disease Control and Prevention (CDC) Youth Risk Behavior Survey of 15,425 high school students in 50 states and the District of Columbia found that on an average school night, 7.5% obtain optimal sleep (>9 hours), 23.9% report "borderline" sleep (8 hours), and 68.6% report insufficient sleep (<8 hours). The 2011 National Sleep Foundation poll found only 14% of teenagers between the ages of 13 and 18 report getting 9 or more hours of sleep on weeknights.

- A 2009 study of 384 students from three Midwest high schools found 91.9% slept less than 9 hours on school nights, with 10% sleeping less than 6 hours each night. The 2007 CDC Youth Risk Behavior Survey found that nationwide, on an average school night, 68.9% of students reported sleeping less than 8 hours, 23.5% reported getting 8 hours, and 7.6% reported getting 9 or more hours. The 2006 National Sleep Foundation poll found only one in five adolescents getting the recommended 9 or more hours of sleep per night.

- In 2008 Norwalk Hospital sleep experts noted that the "often serious impact of this chronic under-sleeping is now evident in both high school and middle school students. This pattern of rising sleep debt during the week followed by weekend catch-up still leaves most teens sleep-deprived by an estimated 10 hours per week." In 2009, writing for the journal, Developmental Neuroscience, researchers again commented, "Sleep deprivation among adolescents is *epidemic*".

- "Sleep deprivation among adolescents appears to be, in some respects, the norm rather than the exception in contemporary society. Because of a multitude of intrinsic and environmental factors, adolescents are particularly vulnerable to disturbed sleep and are one of the most sleep deprived age groups in the country." It has been shown that "adolescents' increased sleepiness is similar to the clinical level of sleepiness presented by patients with severe sleep disorders."

- For most U.S. secondary students, circadian biology collides with early morning classes five days a week, leaving many "pathologically sleepy".

- Most U.S. high schools begin before 8 o'clock while the sleep inducing hormone, melatonin, still pressures adolescents. The circadian system manages a sleep/wake cycle in adolescents which runs from approximately 11 p.m. to 8 a.m. The sleep pressure rate, or homeostatic drive - the biological trigger that causes sleepiness – slows down in adolescence. "There is clear evidence for a phase shift during adolescence, with adolescents going to bed later and rising later than children. This phase shift is largely biological, with adolescents typically unable to fall asleep at earlier times."

- "The vast majority of adolescents do not get enough sleep. Research has shown that the average teenager needs 9 to 9-1/4 hours of sleep a night. This is not all that much less than school-aged children need. However, the average amount of sleep that teenagers get is about 7 hours on school nights. (Mindell & Owens, Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems (Lippincott Williams & Wilkins, 2nd ed. 2010, p. 258).

- Professor of Neurology and Director of the Minnesota Regional Sleep Disorders Center, Mark Mahowald, explains: "All of the research that has been done shows that older adolescents need more sleep than younger ones. They fall asleep later and wake up later to get the sleep they need. Despite these two facts, almost all districts start the senior high schools first. We're sending then to school *during the last one-third of their sleep cycle*. It's comparable to adults getting up at 3 a.m. or 4 a.m.

ADOLESCENT CIRCADIAN TIMING, RESTORATION & STRESS

- Recent studies demonstrate "adolescent changes in sleep (delayed sleep phase and disrupted sleep) are evident prior to the bodily changes puberty". (Wolfson & Richards, Oxford Univ. Press., El Sheikh ed. 2011), p. 268). "Young people have special needs during adolescent development that are related directly to their intrinsic sleep cycles." The sleep pressure rate, or homeostatic drive – the biological trigger that causes sleepiness – slows down in adolescence. Homeostatis relates to the neurobiological need to sleep; the longer the period of wakefulness, the more pressure builds for sleep and the more difficult it is to resist.

- Inadequate exposure to short-wavelength (blue) light further delays the adolescent sleep/wake cycle, pushing back the onset of melatonin by about six minutes for each morning light-deprived day. According to Mariana Figueiro, Ph.D., Assistant Professor and Program Director at Rensselaer Polytechnic Institute's Lighting Research Center, "As teenagers spend more time indoors, they miss out on essential morning light needed to stimulate the body's 24-hour biological system which regulates the sleep/wake cycle."

  The problem is that today's middle and high schools have rigid schedules requiring teenagers to be in school very early in the morning. These students are likely to miss the morning light because they are often traveling to and arriving at school before the sun is up or as it's just rising. This disrupts the connection between daily biological rhythms, called circadian rhythms, and the earth's natural 24-hour light/dark cycle" explains Figueiro.

- "Sleep…helps to restore both mind and body. The body's engines are able to slow down and cool off when we sleep, decreasing the metabolic processes, heart rate, respiration, digestion, and body temperature. Sleep can also be a time of increased healing or, in children, a time of accelerated growth." (Abaci, Take Charge of Your Chronic Pain: The Latest Research, Cutting-Edge Tools (Globe Pequot Press 2010) p. 241). Deep sleep coincides with the release of growth hormone in children and your adults. Sleep seems to be particularly important during the periods of brain maturation. (Across species, maturing individuals sleep more than fully mature individuals.")

- "Adolescent sleep systems appear to become more vulnerable to stress at a time when social turmoil and difficulties are often increasing." Restricted sleep and interrupted circadian timing, discussed *infra,* serve as environmental/physiological stressors in humans. (Wise, Hopkin, & Garland, Handbook of Aviation Human Factors (CRC Press 2nd ed. 2009) p. 18-3) Sleep loss means sustaining wakefulness longer which stresses the body, leading to "additional problems". "Prenatal development, infancy, childhood and adolescence are times of increased vulnerability to stressors. The presence of stressors during these critical periods can have prolonged effects, such as sustained cacostasis (defective homeostatis, dyshomeostatis, distress) that can last the entire lifetime of an individual."

- Most districts set the earliest starting time for older adolescents and the latest starting time for younger children. "Ironically, the school starting time moves earlier as children's grade advances. Although school starts earlier, children cannot adjust their bedtime accordingly, and this could result in sleep deprivation. Subsequently, they are sleepy in the morning and become more alert in the afternoon when school is almost over." (Cardinali, Chronoeducation: How the Biological Clock Influences the Learning Process, published in The Educated Brain: Essays in Neuroeducation (Batro, Fisher, & Léna, edit., Cambridge Univ. Press 2008) p. 121). "Increasing societal demands promoted by a 24/7 culture over the past three decades have contributed to even earlier school start times for both middle and high school students."

- Early rise times also interrupt a critical sleep phase. "Getting adequate dream (rapid eye movement ([REM]) sleep is essential to perceptual, cognitive, and emotional processing. Selective REM sleep deprivation has been demonstrated to cause symptoms of irritability and moodiness, as well as problems with memory. The issue of under-sleeping adolescents takes on added significance when one considers that waking up too early costs the sleeper mostly REM sleep which predominates during the last two to three hours of a night's sleep."

  In REM sleep, many parts of the brain are as active as at any time when awake. One study found that REM sleep affects learning of certain mental skills. People taught a skill and then deprived of non-REM sleep could recall what they had learned after sleeping, while people deprived of REM sleep could not. Associate Professor of Psychology Avi Sadeh, a leading authority in this field, has concluded that in teens "A loss of one hour of sleep is equivalent to [the loss of] two years of cognitive maturation and development." Harvard Professor of Sleep Medicine Susan Redline, M.D., M.P.H., notes that 8 a.m. classes begin too early for adolescent students to obtain sufficient sleep and serve to interrupt REM sleep.

- In most school districts, little has changed since a 2005 study published in "Pediatrics", the official Journal of the American Academy of Pediatrics, observed, "School schedules are forcing [adolescents] to lose sleep and to perform academically when they are at their worst."

ACADEMIC PERFORMANCE

- Sleep loss is associated with "brief mental lapses in attention during simple tasks that can be partially offset by increased effort or motivation". Tiredness and fatigue, however, tend to diminish motivation, particularly for tasks perceived as boring or tedious. Sleep deprivation can "sometimes mimic or exacerbate symptoms of ADHD (attention deficit/hyperactivity disorder), including distractibility, impulsivity, and difficulty with effortful control of attention." There is also evidence that sleep deprivation has marked influences on the ability to perform complex tasks or tasks that require attention in two or more areas at the same time.

- Memory consolidation, long-term recall, and retrieval, particularly of novel material, are all affected by sleep restriction. "Installing new memories – i.e., learning – clearly benefits from, if not depends upon, intervals of normal sleep." "No getting enough sleep may result in problems with attention, memory, decision-making, organization, and creativity, all of which are clearly important for success in school." (Mindell & Owens, Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems (Lippincott Williams & Wilkins, 2nd ed, 2010) p. 258).

- A 2010 meta-analysis (statistical method combining different study results) of 61 studies found poor sleep quality, insufficient sleep and sleepiness significantly associated with worse school performance among students 8-18 years of age.)

- A 2007 study led by Holy Cross Professor of Psychology Amy Wolfson compared two New England middle school with different start times (7:15 a.m. vs. 8:37 a.m.). "Previous research demonstrated that high school students benefit when school start times are delayed by over one hour. In particular, Wahlstrom (2002) found that attendance rates improved, continuous enrollment remained the same or increased, grades showed slight improvement, and students reported bedtimes similar to students in school that did not change start times when obtaining one more hour sleep on school nights.

  The present study adds to the field by demonstrating that middle school students are also at an advantage when school start times are delayed. Results reveal that seventh and eighth graders attending an early starting middle school are obligated to wake up earlier in the morning to attend school and are not compensating by going to bed earlier through the school year. As a result, these young adolescents are getting significantly less sleep than their peers at a later starting school and report more irregular weekly sleep patterns, increased daytime sleepiness, and more sleep-wake behavior problems.

  The seventh and eighth graders at the early starting middle school obtained about ¾ hour less sleep each night, which amounts to about 3.5 hours less sleep over a 5-night school week. Furthermore, after students had been on their school schedules for over 6 months, those at the early starting school reported more sleep-wake behavior problems, raising questions about the longer range negative implications of early start times for young adolescents. In addition to the sleep deficit, school records indicated that students at the earlier starting school were tardy four times more frequently, and eighth graders at the earlier starting school obtained significantly worse average grades than the eighth graders at the comparison later starting school."

PSYCHOMOTOR PERFORMANCE/AUTOMOBILE ACCIDENTS

- "Sleep deprivation, whether from disorder or lifestyle, whether acute or chronic, poses significant cognitive risks in the performance of many ordinary tasks such as driving and operating machinery." (Jeffrey S. Durmer, M.D., Ph.D., Assistant Professor, Department of Neurology, Emory University School of Medicine; David F. Dinges, Ph.D., Professor of Psychology in Psychiatry, Associate Director, Center for Sleep and Circadian Neurobiology, University of Pennsylvania School of Medicine.

- "Both motor and mental acuity suffer when we are sleep deprived, which can lead to dangerous human errors and accidents. Studies done on test subjects with occupations associated with sleep deprivation – including pilots, truck drivers, and medical residents – typically show a greater risk for fatigue-related mistakes and crashes. Accidents related to lost lives and billions of dollars in costs." (Abaci, Take Charge of Your Chronic Pain: The Latest Research, Cutting Edge Tools, (Globe Pequot Press 2010) p. 241)

- There is increasing evidence correlating early start times with higher crash rates among teen drivers. In 1999, school districts in Lexington, Kentucky delayed start times for high school students county-wide by one hour to 8:30 a.m. Average crash rates for teen drivers in the county study in the 2 years after the change in school start time dropped 16.5%, compared with the 2 years prior to the change, whereas teen crash rates for the rest of the stated increased 7.8% over the same time period. Researcher concluded that "allowing adolescents to sleep more on school nights by delaying the start of school not only results in them sleeping more, but also may have a measurable positive effect on their driving safety". In reviewing the study, John Cline, Assistant Clinical Professor of Psychiatry at the Yale School of Medicine, commented, "Given the danger posed to young people from car accidents this is a strong reason in itself to change school start times."

- A 2011 study published in the Journal of Clinical Sleep Medicine found that in 2008, the teen crash rate was about 41% higher in Virginia Beach, Virginia, where high school classes began at 7:20-7:25 a.m., than in adjacent Chesapeake, Virginia, where classes started at 8:40-8:45 a.m. Although a cause and effect relationship has not been established, the Virginia study associates early start times with increased teenage car crash rates. "We were concerned that Virginia Beach teens might be sleep restricted due to their early rise times and that this could eventuate in an increased crash rate," said lead author Robert Vorona, M.D., Associate Professor of Internal Medicine at Eastern Virginia Medical School in Norfolk, Virginia.

EXCESSIVE WEIGHT GAIN

- A 2010 CDC study published in the Journal of the American Medical Association reports that the rate of obesity in U.S. adolescents between the ages of 12 and 19 years was 18.1 percent in 2007-2008. The authors noted that the prevalence of high body mass index in childhood has remained steady for 10 years and has not declined despite prevention efforts.

- Overweight children and adolescents tend to have reduced REM sleep. Although a recent study suggests otherwise, Dr. Redline and other researchers surmise sleep loss may be the missing link in understanding why diet and exercise obesity interventions fail.

- Harvard Professor of Nutrition and Epidemiology Frank Hu observes that there is a close relationship between dietary habits and sleep habits. Sleep is as important as diet and exercise. Sleep deprivation serves to increase production of the appetite-stimulating hormone, ghrelin, sending a signal to the brain to eat, particularly high calorie, high sugar-content foods. By contrast, restricted sleep diminishes the production of leptin, a hormone which suppresses appetite. Production of a third hormone, cortisone, is increased by sleep loss, elevating heart rate and blood pressure. Chronic elevation of cortisone levels increases the risk of weight gain and obesity, with the latter being particularly dangerous for type 2 diabetes and cardiovascular disease.

DELAYING SCHOOL START TIMES – BENEFITS, COUNTERPOINTS, OBSTACLES, AND SOLUTIONS

- Scientists from the Centers for Disease Control and Prevention (CDC) report, "Delaying school start times is a demonstrated strategy to promote sufficient sleep among adolescents." In some districts, however, implementing the change to later start times may be a challenging undertaking. The National Sleep Foundation recognizes eight potential obstacles to adjusting school schedules and proposed possible solutions for each problem.

- Transportation is the first obstacle noted. Fredonia State College Associate Professor Charles Stoddart observes, "The tail of transportation wags the dog of the educational system." The National Sleep Foundation proposes "flipping" the schedules of primary and secondary school children to address transportation since young children can rise early without difficulty, provided they get to bed early enough to ensure the 10-11 hours of sleep they need. However, in discussing obstacle 3, "Other Students and Programs," the Foundation appears to challenge its own advice, noting, "Research is lacking on the effect of school start times on younger students so it is hard to justify their early start."

- As previously observed, even pre-adolescent fifth grade students reported significant sleep deprivation when a start time of 7:10 a.m. was imposed. Mild sleep low produces marked deficits in cognitive development and functioning in school-age children. While sleep scientists report that elementary students are biologically able to begin school by 7:30 a.m., consideration must be given to the effects of long bus rides, and care must be taken to ensure young children will not be left to await transport in darkness.

- University of California and U.S. Air Force Academy economists found a later start time of 50 minutes "has the equivalent benefit as raising teacher quality by roughly one standard deviation. Hence, later start times may be a cost-effective way to improve student outcomes for adolescents."

- School personnel will sometimes oppose the change due to concerns they may have to commute during peak traffic or may have less time with their families. The remaining obstacles or objections to later school scheduling include resistance to change, concerns that students will be in school too late in the day to reasonably participate in sports, jobs, internships, and other extracurricular activities; daycare plans being interrupted, and parents failing to address proper sleeping hygiene with their children.

- Certainly, parents should ensure reasonable bedtimes, impose limits on technology use, and encourage exercise in children to help them get the sleep they need. "We can also help teenagers gain control over their own sleep patterns by teaching sleep and circadian principles in middle and high school health education. Minimizing exposure to light at night, as well as reducing computer or TV usage immediately before bedtime can naturally advance circadian phase. Similarly, incorporating outdoor morning activity into a teenage schedule can reduce trouble falling asleep at night".

- Brookings Institute economists propose districts "consider installing lights for athletic fields that allow students to practice later in the day. While this would certainly be an additional expense, back-to-the envelope calculation suggests that the benefits of later starting times would outweigh the costs. Officials of the Ann Arbor Public Schools, for example, estimate that it costs roughly $110,000 to erect lights for an athletic field, and $2500 annually to operate such lights. Even if a district had to construct and maintain multiple lights at multiple high schools, this investment certainly seems worthwhile compared with the estimated $17,500 per student benefit of later start times."

- There have been few counterpoints to the literature produced by sleep researchers and physicians. In 2006, school officials in the Blue Valley School District in Overland Park, Kansas, developed a summary of the literature and while agreeing that adolescents are not getting sufficient sleep and acknowledging that this will impact academic achievement also posited that it is unclear whether student academic achievement will improve along with a later school schedule and that a solid research base concerning the relationship between sleep and learning has not been established. They suggested that practitioners are not prevented from scouting for ways to ameliorate the sleep problems identified in the cumulative survey data. They also suggested that a longer delay does not necessarily correspond to a greater gain in sleep time.

RESPONSES TO OBJECTIONS

- In 2011, scientists writing for the Journal *Educational Researcher* responded to the remaining objections to later start times:

    - "Many who oppose changing school start times cite the disruption of extracurricular activities as a prohibiting factor. Some school boards have successfully implemented a start time change without disrupting extracurricular activities – and, ironically, without having to schedule after-school activities before school – simply by scheduling events later. In fact, results from the Minneapolis study show that later start times did not significantly affect student participation in after-school activities (Center for Applied Research and Educational Improvement, 1998b). The only problem was that some children were pulled out of class early for away-from-school sporting events (e.g., Center for Applied Research and Educational Improvement, 1998a; National Sleep Foundation, 2005e).

    - Perhaps the most important consideration is that the schools have successfully delayed school start times with minimal complications had adequate time to prepare, which they spent engaged in research, policy analysis, and a healthy discourse with the public. However it should be noted that, in any school district where the start times are changed, it is likely that those directly and indirectly involved in the school system will need to make some degree of sacrifice for the benefits of the students. The inconvenient consequences of changing school start times can be attenuated. There is evidence that with adequate planning and preparation, school boards have been able to delay school start times at acceptable monetary cost (given the enormous potential payoff) and tolerable disruption of community functioning."

- Some parents and school administrators, however, simply aren't persuaded by the scientific evidence, or that delaying start times would make a positive difference. When asked about

adjusting school schedules to comport with adolescent phase delay, former San Mateo County Superintendent of Schools Floyd Gonella, Ed.D., responded, "Trying to adjust school times to sleep patterns has no validity. And even if it does, scientific facts come out and three days later, there's another study countering that." (Edmond Burnes, principal of Battery Creek High School, said he's not convinced delaying start times would have much effect on students at "his school". Mr. Burnes explained that the research with which he was familiar involved different demographics than those of Battery Creek.)

- In the Preface to the Stanford Sleep Book, Professor William Dement notes the "stunning truth" of this observation by former United States Senator Mark Hatfield: "America is a vast reservoir of ignorance about sleep, sleep deprivation and sleep disorders." As Holy Cross Professor of Psychology Amy Wolfson points out, "Although sleep consumes approximately one-third of our lives (50% at early school age), it is often ignored by developmental psychologists, pediatricians, educators, and others who devote their lives to working with children and adolescents. For example, sleep is rarely mentioned in textbooks on adolescent development, child-adolescent sleep topics are infrequently presented at the Society for Research on Child Development meetings (.3% of presentations at the 1995 biennial SRCD meeting), and pediatricians get very little training in sleep medicine." (CAREI Director Kyla Wahlstrom suggests that "pairing the growing body of medical research with the educational outcomes seems to the logical path to argue for changing starting times.)

(References and additional resources can be found at http://schoolstarttime.org/endnotes/)