

Office of the Superintendent of Schools
MONTGOMERY COUNTY PUBLIC SCHOOLS
Rockville, Maryland

January 13, 2015

MEMORANDUM

To: Members of the Board of Education

From: Joshua P. Starr, Superintendent of Schools

Subject: Continuing the Discussion on Changing Bell Times

On June 17, 2014, the Board of Education (Board) received a report that included stakeholder input and the cost implications of changing school bell times by shifting high school start times 50 minutes later, starting middle schools 10 minutes earlier, and extending the elementary school day by 30 minutes. While I have supported the idea of starting high schools later, I felt that the cost of this particular model was prohibitive. Mrs. Patricia O’Neill, then Board vice president, introduced the following resolution that was adopted unanimously by the Board of Education:

Resolved, That the Board of Education requests the superintendent of schools to review low-cost options, not to exceed \$10 million, for changing the start times for Montgomery County Public Schools and identify the implications of these options; and be it further

Resolved, That the superintendent of schools presents a report to the Board of Education in time for consideration during the Fiscal Year 2016 Operating Budget request.

During the June 2014 discussion, Board members expressed an interest in looking at different models. The attached report, *Bell Times—Analysis of Additional Options*, identifies five options and several variations within some of these options. The analysis addresses the challenges and advantages for each option. The cost of each model also is provided. During the Board’s discussion on June 17, 2014, Mr. Philip Kauffman, then Board president, requested that staff consider a “split schedule” as one of the models. Staff also was asked to review what Fairfax County Public Schools was doing with bell times and to determine if systems of comparable size to Montgomery County Public Schools (MCPS) were considering changes to their start times. Further, staff was asked to reexamine the sleep research for any new findings and to determine what the research indicates about the sleep needs for elementary age students. Information in response to these requests is included in the attached report.

The length of the transportation window is the major factor that determines the cost of any

option. It is possible to reduce the need for buses and school bus operators by lengthening the window of operations, which is the amount of time between the first trip of the morning and the last and likewise for the afternoon. The length of the transportation window is noted and discussed for each option identified and reflects an assessment of the additional resources and costs for each option.

The report also identifies the challenges and potential benefits of each of the options. The charts provide further details. The options presented for today's discussion are within the parameters set forth in the Board's resolution. The five options are:

- Shift start times for all schools later (retaining the same order and length of school day) by 20 minutes or 35 minutes
- Start elementary schools first (with variations for start times and length of school day)
- Modify the superintendent's proposal from October 2013 to reduce costs
- "Split" the high school day into two start times (leaving unchanged elementary and middle school start times and length of school day)
- No change (leave bell times as currently designed)

Research Findings

MCPS contracted with Hanover Research (Hanover), an independent research company, to review the literature on the sleep needs of both teens and elementary-age children. Hanover's research report, *School Start Times, Sleep, and Student Outcomes*, is attached to the Bell Times—Analysis of Additional Options report as Appendix D. Extensive review of sleep research also may be found in the *2013 Bell Times Work Group Report*.

In summary, the Hanover report's findings are similar to our previous research. The body of research on school start times does not provide conclusive evidence that start times impact student achievement. There is, however, research that indicates the positive impact of sleep on wellness factors, such as increasing problem solving, decreasing vehicle accidents, and improving daytime sleepiness.

In addition, we asked Hanover to provide MCPS with research findings regarding the sleep needs of elementary-age students. The research on sleep outcomes for elementary-age children is limited. Elementary school start times vary in their impact on student achievement. Elementary school students (ages 5 to 12 years) require 10 to 11 hours of sleep per night. The limited studies that are available indicate that a lack of sleep has a negative impact on elementary-age children.

Study of Safe and Healthy School Hours for Maryland Public Schools

On December 22, 2014, the Maryland Department of Health and Mental Hygiene (DHMH) released a report on its *Study of Safe and Healthy School Hours for Maryland Public Schools* to the Maryland General Assembly and Governor Martin O'Malley. The study was conducted

pursuant to Chapter 620 of the Acts of 2014 that required DHMH to “review the science on the sleep needs of children and adolescents, including the effects of sleep deprivation on academic performance and benefits of sufficient sleep; review and study how other school systems have implemented alternative school day starting times and how various activities in those school systems were impacted and scheduled around the changes; and make recommendations regarding whether public schools should implement a starting time of no earlier than 8:00 a.m.”

The Executive Summary of the report is attached to the **Bell Times—Analysis of Additional Options** report (Appendix C). Both DMHM and the Maryland State Department of Education endorsed a recommendation to “encourage the Maryland State Board of Education use its authority (specified in Md. Code Ann., Ed. § 2-205) to advise local school systems of the benefits of later school start time policies, and to encourage them to conduct feasibility studies regarding the implementation of school starting times of 8:00 a.m. or later.”

Superintendent’s Recommendation

Given the cost implications and the outlook for the Fiscal Year (FY) 2016 Operating Budget and challenges presented by each of the options discussed in the report, I recommend that the Board of Education only considers no-cost options (*Shift Start Times for All Schools Later or Leave Bell Times Unchanged*). The most practicable of the no-cost options is for all schools to start and end 20 minutes later. The cost implications are inconsequential and asking students, staff, and parents to adjust their routines by 20 minutes seems reasonable. Although 20 minutes is not ideal for extending sleep time, it is a move in the right direction, and it will allow the potential for some extended sleep for all involved.

I have been consistent in my support of and my belief that bell times is important to student success and well-being, but must be viewed in the context of other priorities that impact students as well as staff, families, and the broader community. Whenever there is change, it will impact many. Should the Board of Education decide to move forward with my recommendation to consider only those options that are no-cost, and if it chooses to adopt the 20 minute shift, we must be ready to work with our communities and schools that we serve.

JPS:LAB:lsh

Attachment

Montgomery County Public Schools

Bell Times—Analysis of Additional Options

January 2015

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Executive Summary

In October 2013, Montgomery County Public Schools (MCPS) superintendent of schools, Dr. Joshua P. Starr, presented to the Montgomery County Board of Education (Board) a recommendation to consider delaying high school start times by 50 minutes. The recommendation also started middle schools 10 minutes earlier and did not change the elementary start times but extended the elementary school day by 30 minutes to accommodate needed adjustments to the transportation plan. Further, the addition of 30 minutes to the elementary school day would enhance the time spent in school by adding time for art, music, physical education, or a foreign language and/or extending lunch and recess. The recommendation was based on the findings of the 2013 Bell Times Work Group that MCPS high school students would benefit from later start times.

During the months following the superintendent's recommendation, MCPS sought feedback from a broad range of stakeholders, including students, staff, parents, and other community members, through an extensive outreach effort including numerous community town hall meetings, surveys, an e-mail drop box, and other avenues of input. On June 17, 2014, the superintendent of schools presented a report to the Board that included a summary of the wide range of feedback and the costs of implementing this plan, including the additional transportation costs and the cost to extend the elementary school day by 30 minutes. A summary of the outreach efforts were included in the June 2014 *Superintendent's Proposal on Changing Bell Times: Review of Stakeholder Input and Analysis of Operational Impact*. The superintendent did not recommend that the Board proceed with this plan due to the high cost to implement it and the fiscal challenges that MCPS likely would be facing in Fiscal Year (FY) 2016 and FY 2017. The Board carefully considered the report and passed a resolution requesting that the superintendent review lower-cost options, not to exceed \$10 million, for changing the start times and identify the implications of these options. The Board also asked for information on what is referred to below as a "split" schedule—starting high schools at two times; an analysis of a similar Fairfax County Public Schools (FCPS) proposal and factors that made the FCPS proposal less costly than the MCPS proposal; and an updated review of available sleep research.

Each option presented in this report includes estimated costs and a brief summary of the implications of the changes. The options that were considered for this report include:

- Shift start times for all schools 20 minutes or 35 minutes later (retaining the current order and length of school day)
- Start elementary schools first (with variations for start times and length of school day)
- Modify the superintendent's October 2013 proposal to reduce costs
- "Split" the high school day into two start times (leaving unchanged elementary and middle school start times and length of school day)
- Leave bell times unchanged

Introduction

The current bell times schedule for Montgomery County Public Schools (MCPS) was designed in 1993 and began as a cost savings measure that has been effective in managing the transportation needs of certain programs such as magnet programs, immersion programs, consortia, and other special programs that have been started since then. While it is the most cost effective option yet developed, the bell schedule created a 7:25 a.m. high school start time that was a topic of debate in Montgomery County in the late 1990s and then again over the past few years. The 7:25 a.m. start means that most high school students board buses by 6:45 a.m. While the start time may be considered problematic for high school students getting sufficient sleep, the school end time for high schools has been supported in the years since it was implemented, as many high school students use the after-school hours for employment, internships, caring for younger siblings, or after-school extracurricular activities. There is significant concern that high school end times after the current 2:10 p.m. dismissal would create some limitations on some of these responsibilities and interests.¹

Adjustments to the MCPS bell times schedule were considered by the Montgomery County Board of Education (Board) in 1997–1999, and most recently in 2013–2014. Each time, the key concerns associated with suggested changes have been the impact on traditions that have developed about how high school students currently use after-school hours; the transportation costs associated with other potential schedules; and the impact of changing the schedule on elementary school and middle school students, their parents, MCPS staff, and the community.

The formula for transporting a large number of students in the most cost-effective manner possible is to reuse a bus fleet as many times as possible over the longest possible window of time, and still maintain acceptable start and end times for schools at all levels. Since 1993, and during intervening years of severe budget shortages, MCPS has refined this formula to create the safest, most cost-effective, and efficient transportation service possible for a school system that transports approximately 100,000 students daily.

While the formula is straightforward in concept, the logistical reality in MCPS is complex. The transportation structure in place since 1993 depends on four start times. The order of opening schools used by MCPS currently starts with high school, then middle school, then two separate opening times for elementary schools. Prior to 1993, MCPS elementary schools started at varying times, the earliest beginning at 8:00 a.m.² and the latest start at 9:25 a.m. The half-hour differential between the length of the day at high and middle schools (with a 6-hour and 45-minute day) and elementary schools (with a 6-hour and 15-minute day) is used during the morning rush hour to allow delays due to the volume of traffic.

Many parents who have participated in discussions about bell times expressed a preference for a school day that starts about 8:00 a.m. and ends at approximately 3:00 p.m. However, the cost of

¹ A 2014 MCPS survey showed that 19 percent of high school students perceived a later start time would make it harder for them to pick up a sibling after school; 46 percent thought it would be harder to get a job after school; 49 percent thought it would be harder to participate in athletic practices or events; and 52 percent thought it would be harder to participate in after-school activities or clubs. MCPS, Superintendent's Proposal on Changing Bell Times: Review of Stakeholder Input and Analysis of Operational Impact, June 2014, p. 13.

² MCPS, Changing Bell Times: Report of the Bell Times Work Group, January 1998, p. 2.

opening all schools at the same time is not practical as it would nearly quadruple the existing MCPS transportation fleet and budget.

MCPS and neighboring school districts in Maryland and Virginia are aware of the emerging research describing the potential health and safety benefits of high school students getting more sleep which supports the body of research that has developed since the mid-1980s. Each school district comes to the issue of more sleep for teenagers with its own traditions, constraints, and priorities. In Montgomery County, tradition is for high schools to start first, then middle schools, with elementary schools starting last. Conversely, in Loudoun County, Virginia, the tradition is for most elementary schools to start at 7:50 a.m., followed by middle schools, then high schools starting at 8:55 or 9:00 a.m. In Fairfax County, Virginia, the tradition is for elementary schools to start throughout the morning at various times between 7:40 and 9:20 a.m., and a recently approved schedule, to go into effect in the 2015–2016 school year, will start middle schools at 7:30 a.m. before high schools that will start at 8:15 a.m. Anne Arundel County Public Schools is currently considering four options but has not taken any action at the time of this publication.³

In October 2013, Dr. Joshua P. Starr, MCPS superintendent of schools, presented to the Board a recommendation to consider delaying high school start times by leaving elementary start times unchanged and starting middle schools 10 minutes earlier. The proposal pushed back high school start times by 50 minutes and extended the elementary school day by 30 minutes to accommodate needed adjustments to the transportation plan and to enhance the time in school for elementary school students by adding time for art, music, physical education, a foreign language, and/or extending lunch and recess. The recommendation was based on the review of available research by the 2013 Bell Times Work Group and their findings that the current MCPS high school start time of 7:25 a.m. may negatively impact the ability of MCPS high school students to get sufficient sleep.

During the months following the superintendent’s October 2013 recommendation, MCPS sought feedback from a broad range of stakeholders, including students, staff, parents, and other community members through an extensive outreach effort that included surveys, town hall meetings, e-mail drop box, and other avenues for input. The public input process that followed the announcement of the superintendent’s recommendation revealed the following:

- While 78 percent of parents surveyed⁴ supported the shift of high school start times, community forum participants expressed concern about the portion of the October 2013 proposal that called for making the elementary school day the same length as middle and high school days.
- Elementary school students and elementary school staff responded least favorably to the recommendation.
- Parents and middle school students who were impacted the least (a 10-minute adjustment) were most in favor of the recommendation.
- High school students and high school staff members were evenly divided in their support and opposition.

³ See Appendix A

⁴ MCPS, *Superintendent’s Proposal on Changing Bell Times: Review of Stakeholder Input and Analysis of Operational Impact*, June 2014, p. 10.

On June 17, 2014, the MCPS Board considered the broad-based feedback to the October 2013 recommendation. In response to the mixed feedback and the significant costs of the recommendation, the Board passed a resolution requesting that the superintendent of schools review lower-cost options, not to exceed \$10 million, for changing the start times and identify the implications of these options. The Board raised additional issues by asking for more information on what is referred to below as the “split” schedule—starting high schools at two times; analysis of a similar Fairfax County Public Schools (FCPS) proposal and factors that made the FCPS proposal less costly than the MCPS recommendation; and an updated review of sleep research.

The report that follows describes five strategies for modifying bell times, all at costs not exceeding \$10 million. The strategies include:

- Shift start times for all schools 20 minutes or 35 minutes later (retaining the current order and length of school day)
- Start elementary schools first (with variations for start times and length of school day)
- Modify the superintendent’s recommendation from October 2013 to reduce costs
- “Split” the high school day into two start times (leaving unchanged elementary and middle school start times and length of school day)
- Leave bell times unchanged

The Balance

In order to change bell times and still stay within the \$10 million limit put forward by the Board, balancing three factors of time becomes very important. The first factor is the bell time for any school and whether it is too early or too late. The second factor is the amount of time between the first and last bus trips in the mornings and first and last trips in the afternoons, discussed below as the transportation “window of operation.” The third is how these elements and the length of the school day interact with the hours of daylight.

Time is money, and this is particularly true of transportation costs. What is needed is a balance that starts schools at reasonable times while using buses and drivers efficiently. Lengthening the window of operation reduces the number of buses and drivers needed, maximizing the number of trips each bus can make daily, and generally saving money.⁵ The current MCPS schedule allows for most buses to make four trips daily, referred to as a four-tier plan.

However, under a four-tier plan, there is a limit to the optimal length of the operational window. Lengthening the window too much causes some schools to start exceptionally early or late, interferes with the sleep/wake patterns of students, and pushes student pick-up and drop-off times

⁵ Each of the four tiers in the current MCPS bell time model requires essentially the same number of buses, about 600 regular routes in each tier. (Special and cross county routes also are equally divided with a buses doing either a high school and a first-tier elementary route or a middle school and a second tier elementary route.) In 1993 there were fewer routes needed at the high school tier and at the second elementary tier. Transportation dollars were saved by having these tiers with fewer bus needs at either end, and the transportation employee’s day was commensurately shortened to achieve savings when routes were not needed at those times. However, since 1993, with the addition of consortium schools (which significantly impact the first or high school tier) and other growth (added to the fourth tier or second elementary tier to accommodate new elementary schools and added students) and through constant analysis of “best places” to assign special program hours, the DOT has managed to achieve a best case scenario with exceptional balance in the number of buses serving each tier. Now however, with continually increasing demands, program and student population growth, and increased traffic, this balance is pushed to the limit.

to the limits of the hours around dawn and dusk, sometimes referred to as “civil twilight.”⁶ Further lengthening the window unnecessarily increases costs with bus drivers sitting idly while waiting to start runs to their next school. To keep first-tier and last-tier schools from opening too early or too late, the window of operation could be shortened. Shortening the window requires routes to be shorter, reduces the number of stops each bus can make, and necessitates costly increases in the size of the fleet to allow for on-time arrivals. Squeezing four tiers of start times and end times between reasonable hours of civil twilight is made more difficult by the unequal lengths of MCPS school days—6 hours and 45 minute school days for middle and high schools, and 6 hours and 15 minutes for elementary schools.

Obviously, the hours of daylight—especially during winter months—play a significant role in this discussion. Under the current bell schedule, many high school students and some middle school students meet buses before dawn. Many after-school activities keep students from arriving home before dusk. The challenge, therefore, is to find the right balance that incorporates these factors and does so within reasonable cost limitations. There is no easy or simple solution to meeting the demands of time without violating the demand to constrain costs. These factors of time and costs are presented in various models below.⁷

Shift All Start Times Later

One of the central tensions described in the October 2013 report was the desire, on the one hand, for a later start to the high school day, and, on the other hand, an early end to the high school day, even if it meant an early start time. Some high school students have existing commitments to after-school jobs or internships and obligations to provide child care for younger siblings.⁸ In response to these and other concerns presented in the feedback, two models were developed that shift the start of school for all students at all levels later by 20 and 35 minutes and retain the current order of opening (high schools first, followed by middle schools and elementary schools).

CURRENT SCHEDULE DAILY WINDOW OF OPERATION: 190 MINUTES

Level	Time	Length of Day
High School	7:25 a.m.–2:10 p.m.	6 hours, 45 minutes
Middle School	7:55 a.m.–2:40 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:05 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:15 a.m.–3:30 p.m.	6 hours, 15 minutes

⁶ The time around dawn and dusk at which twilight illumination is sufficient under clear weather conditions for objects to be clearly distinguished.

⁷ Each minute of the morning and afternoon window of operation costs approximately \$130,000 in annual salary expenses for transportation employees (bus operators and attendants).

⁸ A 2014 MCPS survey showed that 19 percent of high school students perceived a later start time would make it harder for them to pick up a sibling after school; 46 percent thought it would be harder to get a job after school; 49 percent thought it would be harder to participate in athletic practices or events; and 52 percent thought it would be harder to participate in after-school activities or clubs. MCPS, *Superintendent’s Proposal on Changing Bell Times: Review of Stakeholder Input and Analysis of Operational Impact*, June 2014, p. 13.

SHIFT START TIMES FOR ALL SCHOOLS LATER—MODEL 1 WITH A 20-MINUTE DELAY

COST: \$0/MINIMAL

DAILY WINDOW OF OPERATION: 190 MINUTES (NO CHANGE)

Level	Time	Length of Day
High School	7:45 a.m.–2:30 p.m.	6 hours, 45 minutes
Middle School	8:15 a.m.–3:00 p.m.	6 hours, 45 minutes
Elementary School Tier 1	9:10 a.m.–3:25 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:35 a.m.–3:50 p.m.	6 hours, 15 minutes

SHIFT START TIMES FOR ALL SCHOOLS LATER—MODEL 2 WITH A 35-MINUTE DELAY

COST: \$0/MINIMAL

DAILY WINDOW OF OPERATION: 190 MINUTES (NO CHANGE)

Level	Time	Length of Day
High School	8:00 a.m.–2:45 p.m.	6 hours, 45 minutes
Middle School	8:30 a.m.–3:15 p.m.	6 hours, 45 minutes
Elementary School Tier 1	9:25 a.m.–3:40 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:50 a.m.–4:05 p.m.	6 hours, 15 minutes

Perhaps the most desirable feature of the start school later models is that all levels are impacted equally and in an incremental fashion. An advisory group of elementary, middle, and high school principals expressed support for a 20 minute later shift for all levels. These models retain the desired feature, as expressed in feedback comments, of the 6 hours, 15 minute school day for elementary students and retains the order of opening so that older siblings who care for elementary-age siblings are able to get out of school before the elementary schools. This model responds to concerns that middle school students with sleep needs similar to high school students gain additional sleep time. Model 2 satisfies the concern among some that no schools start before 8:00 a.m.⁹

While elementary students’ sleep needs are discussed below, it is acknowledged that later elementary start times are not optimal, for a variety of reasons that include the following: parents needing to leave for work prior to the elementary school bus pick up may need additional child care in the morning, magnet and immersion school students with long bus rides will arrive home later, and students who eat breakfast at school will eat later.¹⁰ The various start and end times proposed for elementary schools are a change from current operations but within the range of customary scheduling options utilized by neighboring school districts.

⁹ The Maryland legislature recently passed legislation authorizing a study to consider requiring all public schools to start no earlier than 8:00 a.m. Should the 8:00 a.m. start time become law, this model would satisfy the requirement. The report of the group conducting the study is due for publication in December 2014.

¹⁰ If the elementary community was to consider a 10-minute extension of the elementary school day, the elementary start times would only be 10 minutes later rather than 20 minutes under Model 1, and 25 minutes rather than 35 minutes in Model 2.

COMPARISON OF ELEMENTARY SCHOOL BELL TIMES

Level	Time	Length of Day
HOWARD COUNTY PUBLIC SCHOOLS		
Elementary School (varies)	8:15 a.m.–2:45 p.m. (earliest) 9:25 a.m.–3:55 p.m. (latest)	6 hours, 30 minutes
BALTIMORE COUNTY PUBLIC SCHOOLS		
Elementary School (varies)	8:40 a.m.–3:10 p.m. (earliest) 9:20 a.m.–3:50 p.m. (latest)	6 hours, 30 minutes
FAIRFAX COUNTY PUBLIC SCHOOLS—TO TAKE EFFECT 2015–2016		
Elementary School (varies) ¹¹	8:00 a.m.–2:45 p.m. (earliest) 9:20 a.m.–4:05 p.m. (latest)	6 hours, 45 minutes
LOUDOUN COUNTY PUBLIC SCHOOLS		
Elementary School ¹²	7:50 a.m.–2:35 p.m.	6 hours, 45 minutes

Start Elementary Schools First

Prior to 1993, MCPS elementary schools started at varying times, the earliest beginning at 8:00 a.m. and the latest start at 9:25 a.m. The length of elementary school days varied from 6 hours to 6 hours, 10 minutes. One strategy for starting high schools later than the current 7:25 a.m. is to reverse the order of opening and return some elementary schools to start times closer to 8:00 a.m. as has been done in the past. Each model presented below starts elementary schools at two different times but shifts those start times to 8:00 a.m. or earlier. The following four models start elementary schools first, and Models 3 and 4 include modest adjustments to the length of the elementary and middle school days:

CURRENT SCHEDULE

DAILY WINDOW OF OPERATION: 190 MINUTES

Level	Time	Length of Day
High School	7:25 a.m.–2:10 p.m.	6 hours, 45 minutes
Middle School	7:55 a.m.–2:40 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:05 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:15 a.m.–3:30 p.m.	6 hours, 15 minutes

¹¹ Variable start times are used by FCPS to maximize efficiency within geographic regions where traffic patterns vary. MCPS made a decision in 1993 to value the benefits of a standardized bell schedule over the marginal benefits of varied start times and believes public resistance to very early and very late elementary schools would be problematic for MCPS based on elementary parents' and staff members' input.

¹² These start times represent the majority of Loudoun County elementary schools. There are three exceptions (two starting at 8:15 and one at 8:00 a.m.).

ELEMENTARY FIRST MODEL 1

COST: \$2.6 M

DAILY WINDOW OF OPERATION: 210 MINUTES¹³

Level	Time	Length of Day
Elementary School Tier 1	7:35 a.m.–1:50 p.m.	6 hours, 15 minutes
Elementary School Tier 2	8:00 a.m.–2:15 p.m.	6 hours, 15 minutes
High School	8:45 a.m.–3:30 p.m.	6 hours, 45 minutes
Middle School	9:15 a.m.–4:00 p.m.	6 hours, 45 minutes

ELEMENTARY FIRST MODEL 2

COST: \$5.2 M

DAILY WINDOW OF OPERATION: 230 MINUTES¹⁴

Level	Time	Length of Day
Elementary School Tier 1	8:00 a.m.–2:15 p.m.	6 hours, 15 minutes
Elementary School Tier 2	8:25 a.m.–2:40 p.m.	6 hours, 15 minutes
High School	9:10 a.m.–3:55 p.m.	6 hours, 45 minutes
Middle School	9:40 a.m.–4:25 p.m.	6 hours, 45 minutes

ELEMENTARY FIRST MODEL 3

COST: \$4.55 M

DAILY WINDOW OF OPERATION: 225 MINUTES¹⁵

Level	Time	Length of Day
Elementary School Tier 1	7:45 a.m.–2:05 p.m.	6 hours, 20 minutes
Elementary School Tier 2	8:15 a.m.–2:35 p.m.	6 hours, 20 minutes
High School	8:50 a.m.–3:35 p.m.	6 hours, 45 minutes
Middle School	9:30 a.m.–4:05 p.m.	6 hours, 35 minutes

ELEMENTARY FIRST MODEL 4

COST: \$3.9 M

DAILY WINDOW OF OPERATION: 220 MINUTES¹⁶

Level	Time	Length of Day
Elementary School Tier 1	7:45 a.m.–2:10 p.m.	6 hours, 25 minutes
Elementary School Tier 2	8:15 a.m.–2:40 p.m.	6 hours, 25 minutes
High School	8:50 a.m.–3:35 p.m.	6 hours, 45 minutes
Middle School	9:30 a.m.–4:05 p.m.	6 hours, 35 minutes

Some members of an advisory group of elementary, middle, and high school principals were receptive to the elementary schools first strategy, suggesting that the early elementary school start time may provide additional planning opportunities for staff and would assist working parents by eliminating the need for morning day care. Starting elementary schools first benefits children who rely on school breakfast programs for their first meals of the day. Further, starting elementary

¹³Requires each transportation employee to receive 20 minutes of additional pay per day but requires no additional routes or buses.

¹⁴Requires each transportation employee to receive 40 minutes of additional pay per day but requires no additional routes or buses.

¹⁵Requires each transportation employee to receive 35 minutes of additional pay per day but requires no additional routes or buses.

¹⁶Requires each transportation employee to receive 30 minutes of additional pay per day but requires no additional routes or buses.

schools first compresses the morning window of operation as short as possible in Models 1 and 2, while still keeping the elementary school day to 6 hours and 15 minutes.¹⁷ The MCPS elementary school day is among the shortest in Maryland,¹⁸ and public comments demonstrated that there is a portion of the MCPS elementary school community that prefers to keep it that way.

The later start time for middle and high schools better aligns with adolescent sleep cycles, and this later high school start time does not come at the expense of middle school students, whose sleep needs are similar. A later middle school dismissal addresses a concern expressed by some that middle school students without afternoon supervision can and do get into trouble.¹⁹

Starting elementary schools first responds to comments from elementary school parents responding to the October 2013 recommendation that expressed support for elementary school schedules that allowed the following:

- Dismiss school early enough to allow elementary students to play outside during afternoon daylight hours (daylight availability after school also factored in comments about walking home from school or getting off the bus before dark); early dismissal times also were desirable for family time, homework completion, and the ability to participate in after-school extracurricular activities (e.g., private lessons, language school, or religious classes).
- Eliminate the need for *both* before *and* after-school day care (e.g., start school early enough for working parents to drop off students on the way to work); several commenters reported that after-school child care was easier to arrange than before-school child care, and early start times were more compatible with the needs of working parents than later start times. However, eliminating or reducing the need for before-school child care may be offset by an increase in after-school child care costs if the elementary school day ends in the early afternoon.
- Do not significantly extend the elementary school day.

Research about optimal school start times for elementary students or sleep/wake patterns in healthy elementary-aged children is extremely limited. Available studies say that elementary students need between 10 and 11 hours of sleep per night, and for younger children, parents play an integral role in the child's sleep-wake cycle through enforced bedtimes.²⁰ What determines that bell times are "too early" or "too late" for students between the ages of 5 and 11 or what constitutes the optimal length of the elementary school day is not documented in available research literature.²¹

While this model might be most responsive to available sleep science about adolescents, concern was expressed about elementary school students waiting at bus stops in the early morning and the lack of after-school supervision for those elementary-age children currently cared for by older

¹⁷ The October 2013 proposal shortened that window an additional 10 minutes, but required lengthening the elementary school day. The afternoon window of operation often is not the same as the morning window of operation. Under the current schedule, *end* times for the various school levels are about 30 minutes apart. It is not possible, however, for schools to consistently *start* and *end* 30 minutes apart because the elementary school day is not the same length as the middle and high school days.

¹⁸ MCPS, Report of the 2013 Bell Times Work Group: Sleep Needs of Students, Scheduling Practices, and Options for Consideration, September 2013.

¹⁹ Law enforcement reports a spike in juvenile crime on weekdays between the hours of 2 and 4 p.m. Source: Federal Bureau of Investigations statistics reported in Changing Bell Times: Report of the Bell Times Work Group, MCPS, January 1998, Attachment A, P.16.

²⁰ See Appendix D: Hanover Report, p. 30.

²¹ See Appendix D: Hanover Report, p. 14

siblings who would get home from school later under this model. The later high school release time complicates high school students' after-school activities. Further, the later start for middle school students raises the concern that students without sufficient morning supervision may have difficulty getting ready for school, making the bus, or getting to school on their own.

The middle school bell times in the October 2013 recommendation (7:45 a.m.) represented a 10-minute adjustment for students in Grades 6, 7, and 8. The feedback gathered during the period that followed the publication of the October 2013 recommendation suggested that middle school students, parents, and staff were receptive to that recommendation, in part, because the changes were modest and because parents and students anticipated benefiting from the later high school schedule in future years.

Significant changes to middle school start times are associated with the strategy of starting elementary schools first as it would put the middle school start times last. Starting middle schools last would represent a substantial difference in the middle school day (for both students and staff) and would require further input and development to address issues such as before-school breakfast programs and after-school extracurricular activities, which could possibly require shifting some before the start of the school day.

Modify October 2013 Recommendation

In response to concerns about costs of the October 2013 recommendation and the length of the elementary school day, the October 2013 recommendation was modified to reduce costs and reduce the extension to the elementary school to no more than 10 minutes. The current schedule, the original October 2013 recommendation, and the two modified models follow:

CURRENT SCHEDULE

DAILY WINDOW OF OPERATION: 190 MINUTES

Level	Time	Length of Day
High School	7:25 a.m.–2:10 p.m.	6 hours, 45 minutes
Middle School	7:55 a.m.–2:40 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:05 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:15 a.m.–3:30 p.m.	6 hours, 15 minutes

SUPERINTENDENT'S ORIGINAL OCTOBER 2013 RECOMMENDED SCHEDULE

COST: APPROXIMATELY \$21 M

DAILY WINDOW OF OPERATION: 180 MINUTES²²

Level	Time	Length of Day
Middle School	7:45 a.m.–2:30 p.m.	6 hours, 45 minutes
High School	8:15 a.m.–3:00 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:35 p.m.	6 hours, 45 minutes
Elementary School Tier 2	9:15 a.m.–4:00 p.m.	6 hours, 45 minutes

²² Requires each transportation employee to receive 10 minutes less pay per day but required 190 additional routes or buses at an estimated cost of \$13 M per year including the savings from reducing transportation staff daily hours.

SUPERINTENDENT’S RECOMMENDED SCHEDULE—MODIFIED MODEL 1

COST: \$5.2 M

DAILY WINDOW OF OPERATION: 230 MINUTES²³

Level	Time	Length of Day
Middle School	7:35 a.m.–2:20 p.m.	6 hours, 45 minutes
High School	8:15 a.m.–3:00 p.m.	6 hours, 45 minutes
Elementary School Tier 1	9:20 a.m.–3:35 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:45 a.m.–4:00 p.m.	6 hours, 15 minutes

SUPERINTENDENT’S RECOMMENDED SCHEDULE—MODIFIED MODEL 2

COST: \$5.85 M

DAILY WINDOW OF OPERATION: 235 MINUTES²⁴

Level	Time	Length of Day
Middle School	7:30 a.m.–2:00 p.m.	6 hours, 30 minutes
Elementary School Tier 1	8:00 a.m.–2:25 p.m.	6 hours, 25 minutes
High School	8:45 a.m.–3:30 p.m.	6 hours, 45 minutes
Elementary School Tier 2	9:30 a.m.–3:55 p.m.	6 hours, 25 minutes

Modified Model 1 retains the 8:15 a.m. start time for high schools that was considered desirable by 78 percent of parents and the order of opening proposed in the October 2013 recommendation. Under Model 1, the length of the elementary school day reverts to the current 6 hours and 15 minutes in response to concerns expressed by elementary school parents and staff.²⁵

The middle school day is 20 minutes earlier than the current school day under Modified Model 1, and the 7:30 a.m. middle school start time in Modified Model 2 is 25 minutes earlier than the current start time. Modified Model 2 requires modest adjustments to the length of the middle school and elementary school days. It works from a transportation perspective. However, the 8:45 a.m. high school start time interjected between the first and second tier elementary start times raises concerns about scheduling in-service training and other administrative meetings of elementary staff across the district and staff who split assignments between two schools (often on different schedules).

One factor contributing to the middle school student, parent, and staff support for the original October 2013 recommendation was the incremental, 10-minute adjustment from the current schedule. The 25-minute earlier shift in Modified Model 2 may raise concerns about the sleep needs for middle school students. Further, the early dismissal of middle schools creates the potential for more unsupervised time after school.

²³ Requires each transportation employee to receive 40 minutes of additional pay per day but requires no additional routes or buses.

²⁴ Requires each transportation employee to receive 45 minutes of additional pay per day but requires no additional routes or buses.

²⁵ While the original October proposal left elementary school start times unchanged by extending the day 30 minutes, the 6 hours, 15 minutes elementary school day in the revised model requires delaying the elementary school start times by 30 minutes.

Some of the feedback gathered during the public input phase to the October 2013 recommendation included concerns that the later elementary start times did not take advantage of the early morning period of time when younger students likely were alert and ready to learn. Late elementary start times also mean a late breakfast for those students receiving breakfast at school. This has the potential to impact more than 17,000 students.

“Split” the High School Day

Board members requested more information about the possibility of a “split” high school day that allowed for two start times, leaving unchanged elementary and middle school start times and length of school day.

CURRENT SCHEDULE

DAILY WINDOW OF OPERATION: 190 MINUTES

Level	Time	Length of Day
High School	7:25 a.m.–2:10 p.m.	6 hours, 45 minutes
Middle School	7:55 a.m.–2:40 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:05 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:15 a.m.–3:30 p.m.	6 hours, 15 minutes

SPLIT HIGH SCHOOL DAY

COST: TO BE DETERMINED

DAILY WINDOW OF OPERATION: 190 MINUTES²⁶

Level	Time	Length of Day
1 st Period High School Start	7:25 a.m.–2:10 p.m.	6 hours, 45 minutes
3 rd Period High School Start No Transportation Provided	9:05 a.m.–3:50 p.m.	6 hours, 45 minutes
Middle School	7:55 a.m.–2:40 p.m.	6 hours, 45 minutes
Elementary School Tier 1	8:50 a.m.–3:05 p.m.	6 hours, 15 minutes
Elementary School Tier 2	9:15 a.m.–3:30 p.m.	6 hours, 15 minutes

While two high school start times may appear to give high school students start time options, those options come at significant costs to course offerings, availability of teachers for individual student assistance, in addition to concerns about staffing, athletic programs, and equity. There are significant equity concerns with this option because transportation would be provided only one time—namely, at the early hour so students with less means or no personal transportation will still have to arrive at the earlier time. Students who have their own means and transportation will have an easier time getting to school if they elect the later start time. Some of the challenges to implementing a split high school day follow:

- *Students will have fewer opportunities to seek teacher assistance outside of class. High school teachers often make themselves available for individual student assistance before*

²⁶ No transportation is provided for the second high school start time under this option; therefore, no transportation costs are shown. Costs for school staffing and other supporting elements to be determined.

school, after school, or during their lunch hours. This works well when students and teachers have a common lunch period, for those teachers who voluntarily give up their lunch hours. But for those students who are in class during teacher lunch periods, before- or after-school teacher availability becomes very important. Under the proposed split model, staggered student and teacher start and end times create the likelihood that there will be no time before/after school or during lunch that a student may be able to obtain assistance from a particular teacher.

- *Course offerings will be reduced.* “Singleton” courses are those offered only once a day, typically specialty elective courses or Advanced Placement (AP) courses. The number of times a high school course is offered during the day is driven by the number of students who want or need to take each course, and when there are not enough students to schedule a course, the course is not offered at the school. When creating a master high school schedule, high schools strategically spread out singletons across the seven periods so that students desiring one or more singletons have greater chances of being able to fit them into their schedules. With some students starting school later than others, the scheduling of singletons would be limited to classes in the middle of the day to ensure each student who wants to take a course can. With fewer periods to schedule classes that are offered only once during a day, course availability for students, especially juniors and seniors, will be reduced, and students may not have the ability to schedule desired or needed singleton classes.
- *This may not be an option for International Baccalaureate (IB) and magnet programs.* Singleton courses are common in these programs.
- *Increased staffing may be required for some courses.* Students in special self-contained programs including Multidisciplinary Educational Training and Support (METs) and special education are scheduled in a small group for the majority of the school day. If some students in the program choose to start later while others start earlier, the program will need to be double staffed to ensure there is appropriate staffing throughout the day. Because these are very low ratios (sometimes as low as 6 students to 1 teacher and 2 paraeducators), there could be time when there are only 1 or 2 students.

The split schedule raises several challenges related to the athletic program, which include the following:

- Start times for many sports—tennis, baseball, softball, cross country, and golf would need to remain the same (3:30 p.m.) due to daylight constraints. This option would cause late shift students to miss an inordinate amount of classroom instruction.
- Coaches assume multiple roles in the school building, including serving as academic mentors to student athletes. This role involves time at lunch and before and after school to allow for coaches to meet with student athletes and teachers. Also, many coaches supervise a study hall and/or academic intervention programs for student athletes. This support would be difficult to implement under the “split” model because the schedules of coaches would not be in concert with the schedules for some/many student athletes.
- The “split” schedule would impact the availability of facilities for practices and contests—both indoor and outdoor. Swimming pools, non-MCPS fields and facilities, golf courses,

and park facilities often are used by community members during evening hours. Schools would have a much more difficult time procuring these types of public facilities if the start time for practices is moved to a later time. The later that practices start and end, the greater the potential for conflict with community groups.

Leave Bell Times Unchanged

Another possible choice for the Board to consider is to leave bell times unchanged and provide other options for students. For example, some modifications could include making abbreviated school schedules more readily available to high school students.

Abbreviated schedules are currently an option for high school students and are used for a variety of reasons, including allowing students to leave early for internships or jobs and accommodating students who require a shorter schedule for medical or other reasons. For example, at one MCPS high school, more than 100 students have been granted abbreviated schedules during the 2014–2015 school year to participate in Career and Technology Education (CTE) internships such as child development.

Abbreviated schedules are typically not possible for students in IB or magnet programs because of course scheduling constraints, nor are they typically approved for freshmen or sophomores before they have had the opportunity to obtain sufficient credits to complete high school graduation requirements within four years. Transportation is not provided for students arriving late or departing early, making abbreviated schedules viable only for students who can provide their own transportation. Further, the availability and procedures for obtaining an abbreviated schedule are not widely known among parents/students, so the number of students seeking such schedules is limited.

Another strategy that could allow high school students to start later is to expand the use of online courses. MCPS currently offers few online courses, and most students using online courses to obtain credit are registered with other course providers, such as universities or other vendors.

Emerging best practices show that not all students can successfully complete online courses independently. One reason some students struggle with independent online courses is lack of student maturity. More success has been demonstrated with a hybrid model that includes periodic check-ins providing in-person teacher supervision, but hybrid models would have potential for additional cost implications. Another difficulty is that online versions of introductory courses can leave students ill-prepared for subsequent courses if all core material is not covered or addressed in a manner compatible with upper level courses. Therefore, online courses tend to be most appropriate for elective credit or to accommodate specialized student interests in subjects that will not have a direct bearing on subsequent courses, another reason they are typically not taken by freshmen and sophomores. Inequity is a concern for students without convenient access to computers and Internet access. As with abbreviated schedules, transportation is not provided for students arriving late or departing early.

Fairfax County Public Schools Proposal

On October 23, 2014, the Fairfax County, Virginia Board of Education approved a revised bell time schedule to take effect in the 2015–2016 school year, as follows:

FAIRFAX COUNTY PUBLIC SCHOOLS REVISED SCHEDULE—EFFECTIVE 2015–2016

Level	Time	Length of Day
Middle School	7:30 a.m.–2:15 p.m.	6 hours, 45 minutes
High School (varies)	8:00 a.m.–2:45 p.m. (earliest) 8:10 a.m.–2:55 p.m. (latest)	6 hours, 45 minutes
Elementary School (varies) ²⁷	8:00 a.m.–2:45 p.m. (earliest) 9:20 a.m.–4:05 p.m. (latest)	6 hours, 45 minutes

As described above, the formula for transporting a large number of students in the most cost-effective manner possible is to reuse a bus fleet as many times as possible over the longest possible window of time, and still maintain acceptable start and end times for schools at all levels. Since 1993, and during intervening years of severe budget shortages, MCPS has refined their formula to create the safest, most cost-effective, and efficient transportation service possible for a school system that transports 100,000 students daily. Costs increase when the window of operation is reduced.

Under both the 2015–2016 FCPS revised schedule and the MCPS October 2013 recommendation, middle schools open first, followed by high schools. The morning window of operation for FCPS was reduced by 10 minutes from two hours to one hour, 50 minutes. One of the key differences between MCPS and FCPS operations was that the current MCPS morning window of operation (one hour, 50 minutes) was already shorter than the current FCPS window, and the MCPS October 2013 recommendation shortened it by an additional 20 minutes.

MCPS CURRENT		MCPS 2013 RECOMMENDATION
Earliest a.m.	7:25 a.m. (high school)	7:45 a.m. (middle school)
Latest a.m.	9:15 a.m. (elementary tier 2)	9:15 a.m. (elementary tier 2)
A.M. Window of Operation	1 hour, 50 minutes	1 hour, 30 minutes

FCPS CURRENT		FCPS 2015–2016
Earliest a.m.	7:20 a.m. (high school)	7:30 a.m. (middle school)
Latest a.m.	9:20 a.m. (elementary)	9:20 a.m. (elementary)
A.M. Window of Operation	2 hours	1 hour 50 minutes

In MCPS, the October 2013 recommendation met with some elementary school parent and staff resistance to extending the elementary day to 6 hours and 45 minutes (30 additional minutes daily). In FCPS, the revised schedule to take effect in 2015–2016 is a five-minute adjustment from the 2014–2015 elementary school schedule (from 6 hours, 40 minutes to 6 hours, 45 minutes).

²⁷ Variable start times are used by FCPS to maximize efficiency within geographic regions where traffic patterns vary.

Other differences in the two school districts, described below, impact the cost and public reception to proposals that are nearly identical. The FCPS plan to take effect in the 2015–2016 school year is estimated to cost an additional \$4.9 million and increase their fleet by 47 buses. The costs of the MCPS options presented in this report that increase the windows of operation incur additional costs because they require additional hours for transportation employees, but do not require additional buses.

Longest Routes/Greatest Demand on Buses

- In FCPS, putting middle school before high school gives *more* time for FCPS to complete the longest trip of the morning first.²⁸ First trips are able to start earlier because there are no preceding school drop offs restricting the time drivers may begin picking up students.
- In MCPS, the October 2013 proposal to put middle school before high school gave MCPS *less* time to complete the longest trip of the morning (high school), creating a greater need for additional school buses because the high school runs were sandwiched between the middle school and first tier elementary runs.
- For MCPS to maintain a similar savings, high schools would have to continue to start before middle schools without a preceding school to restrict when drivers may begin picking up students or provide additional time to complete high school runs within the schedule.

Earliest Start Time

For MCPS, the 7:45 a.m. middle school start time in the October 2013 recommendation was a 10-minute adjustment for students in Grades 6, 7, and 8. For FCPS, the new 7:30 a.m. start time will be an adjustment of between 5 minutes later to 35 minutes earlier, depending on the school, as FCPS middle schools currently start between 7:25 or 8:05 a.m. for Grades 7 and 8 (Grade 6 in FCPS is in elementary school in all cases but one).

Latest End Time

For MCPS, the 4:00 end time for Tier 2 elementary schools in the MCPS October 2013 recommendation was 30 minutes later than the current schedule but still 5 minutes earlier than the latest end time for FCPS elementary schools.

Research Update

An independent review of available research literature was requested to examine the sleep needs of elementary school students, with a particular interest in the pattern of waking and falling asleep associated with time of day and the relationship between sleep and various elementary student

²⁸ FCPS and MCPS have about the same number of high schools. However, FCPS middle schools are comprised of Grades 7 and 8, with one exception that has Grades 6 through 8. FCPS has fewer middle schools than high schools making the middle school areas larger and routes longer. From a route design and scheduling perspective, this means that FCPS middle school routes take longer than their high school routes and are FCPS' longest bus runs of the day. Conversely, MCPS has many fewer high schools than middle schools (26—including the Thomas Edison High School of Technology—compared to 38), making the high school routes the longest MCPS routes of the day. So while the FCPS bell schedule, like the MCPS October 2013 proposal, starts middle schools before high schools, this impacts each school district differently.

outcomes. The independent review by Hanover Research also updated available sleep research on adolescents (middle and high school students) presented in earlier MCPS bell time reports.

Some elementary parents and staff responding to the October 2013 recommendation expressed concern that the research presented in support of later high school start times focused only on the sleep needs of adolescents (particularly high school students) and not on elementary students. An independent review of the research showed that there was little available comparable research on elementary students. While the independent reviewers were able to locate findings on how much sleep elementary students need and how sleep deprivation affects functioning, there was not a comparable body of research on the circadian rhythms of elementary students.

The findings on elementary school students were as follows:

- *Sleep/wake patterns:* Information about sleep/wake patterns in healthy elementary-aged children is extremely limited. For younger children, parents often play an integral role in the child's sleep-wake cycle through enforced bedtimes. While children younger than 6 years of age typically require daytime naps as well as a long nighttime session, sleep typically becomes consolidated into a single nighttime session when children reach the age of 6 or 7. A finding that preadolescents are found to have early morning preferences, as compared to older children, is based on a study of Grade 6 girls that showed more mature girls favored later hours while less mature girls favored earlier hours.
- *Duration:* Elementary school students (ages 5 to 12 years) require 10 to 11 hours of sleep per night. Students' activities, in addition to enforced bedtimes mentioned above, also affect the amount and quality of sleep. For example, increasing academic demands from school, sports and extracurricular commitments, and use of television, computers, and other devices can disrupt sleep and cause students to go to bed later.
- *Deprivation:* The limited studies that are available indicate that a lack of sleep has a negative impact on elementary-aged children. The cognitive performance of young children is adversely affected by reductions in sleep. Additionally, long-term physical health measures of children, such as obesity rates, were found to be associated with inadequate amounts of sleep.

The Hanover Report also reexamined the available research literature on high school start times. Hanover looked at research released since 2013 and confirmed the key findings of the earlier report that there are health and safety benefits associated with later high school start times. However, Hanover concluded that there is no conclusive evidence that demonstrates that later high school start times result in improved academic achievement for students. The updated review of the literature reiterates that in the teenage population, getting enough sleep helps increase important brain functions vital to the learning process and contributes to lower automobile crash rates, lower rates of obesity, and decreased incidences of depression.

Conclusion

The purpose of this report was to describe potential strategies to adjust the MCPS bell times schedule within the cost parameters set by the Board. All of the strategies described above were considered to meet the objective of starting high schools later to allow high school students more

time to sleep. The options and discussion included provide a range of possibilities that are cost effective and provide the potential opportunity for increasing sleep for high school students.

Almost every strategy impacts the elementary school and middle school schedules, either by moving start times earlier or later, or by changing the times when elementary and middle school students can participate in accelerated courses at middle and high schools, respectively. The various start and end times proposed for elementary schools are a change from current operations but within the range of customary scheduling options utilized by neighboring school districts.

The issue of changing bell times remains a complex one. While the available research indicates there are benefits of a later start time for high school students, implementing such a change presents challenges. Each option included in this report includes myriad advantages and disadvantages for students, staff, and parents that need to be weighed and considered.

Appendices

Appendix A

Options for Anne Arundel County

The Anne Arundel County Public Schools School Start Times Task Force developed four bell schedule options that were presented to the Anne Arundel County Board of Education in October 2014. These options were then disseminated to the public for feedback and further discussion:

- **Option A: High schools begin at 8:30 a.m.;** middle schools begin at 9:30 a.m. and elementary schools begin between 7:50 and 9:15 a.m.
- **Option B: High schools begin at 9:15 a.m.;** middle schools begin between 8:20 and 8:30 a.m. (with one middle school beginning at 9:00 a.m.); and elementary schools begin between 7:40 and 9:15 a.m.
- **Option C: All schools shift 30 minutes later** than current start times.
- **Option D: All schools shift 30 minutes later** than current start times **with a late-start hybrid learning option** for some high school students.

Appendix B

Cost Implications for Bell Times Modification Strategies

Strategy	Model	Cost
CURRENT BELL SCHEDULE		
	+ 20 MINUTES	COST NEUTRAL
	+ 35 MINUTES	COST NEUTRAL
ELEMENTARY FIRST		
	MODEL 1	\$2.6 M
	MODEL 2	\$5.2 M
	MODEL 3	\$4.55 M
	MODEL 4	\$3.9 M
SUPERINTENDENT’S PROPOSED SCHEDULE MODIFIED		
	MODEL 1	\$5.2 M
	MODEL 2	\$5.85 M
“SPLIT” HIGH SCHOOL SCHEDULE		
		COST TO BE DETERMINED

Appendix C

Executive Summary: Study of Safe and Healthy School Hours for Maryland Public Schools

Appendix D

School Start Times, Sleep, and Student Outcomes

Executive Summary

This report is submitted pursuant to Chapter 620 of the Acts of 2014 (House Bill 883), which requires the Office of Public Health Services in the Department of Health and Mental Hygiene (DHMH or Department) to:

“...review the science on the sleep needs of children and adolescents, including the effects of sleep deprivation on academic performance and benefits of sufficient sleep; review and study how other school systems have implemented alternative school day starting times and how various activities in those school systems were impacted and scheduled around the changes; and make recommendations regarding whether public schools should implement a starting time of no earlier than 8:00 a.m.”

In response to this request, Part I, written by DHMH, provides a summary of the scientific literature on sleep physiology and sleep needs of youth, the effects of insufficient sleep on school performance and other parameters impacting academic and overall health and well-being, and the positive outcomes associated with sufficient sleep. Part II, written by the Maryland State Department of Education (MSDE), studies how other school systems have implemented alternative school day starting times. Additionally, a summary table of school districts that have implemented later start times is included. Finally, recommendations on whether earlier start times should be implemented will incorporate all findings.

Children and Adolescents: Maturation Means Less Sleep

While there is not perfect agreement as to what constitutes adequate sleep, there is general consensus among the health care community, including sleep science experts, that school-age children need at least eight hours (adolescents) to 10 hours (young children) of sleep each night. The literature on sleep and academic performance consistently shows that sleep (duration, efficiency, sleepiness) is an important predictor of attention and cognitive ability in children and adolescents. This topic has been studied in racially and economically diverse populations and among school systems in urban, suburban, and rural environments with similar results.

As young people pass from childhood into and through puberty, they take longer to fall asleep. Melatonin, the hormone that signals preparation for sleep, is secreted later in the evening, and shuts off later at night, another physiologic change which contributes to the basis for the later-to-bed, difficult-to-wake pattern of puberty. As children age through adolescence, they spend less time in the phase of sleep which is believed to be critical to brain refreshment and restoration. These normal changes of puberty, factors intrinsic to the child and his or her developmental stage, provide a biological foundation for insufficient sleep and daytime sleepiness in adolescents particularly when an early wake time is imposed.

Extrinsic factors, attributes, or practices in the life or environment of the child that contribute to decreased sleep have also been documented. Early school start time has been identified as one of the strongest predictors of shorter weeknight sleep duration in adolescents. Other factors negatively impacting sleep include social and extracurricular activities; computer, video game, and TV time; and caffeine use. Parental-set bedtime has been found to positively impact sleep duration.

Consequences of Insufficient Sleep

Insufficient sleep, however defined, has been associated with poorer academic performance across multiple age groups, and across several school subjects, including math, science, writing and social studies. With less sleep, children score lower on achievement tests and tests of eye-hand coordination, dexterity and non-verbal concept formation. Conversely, more sleep is associated with improvement in executive function and in measures of attention and impulsivity.

Poor health outcomes, including depression, anxiety, suicidal ideation, and overweight/obesity have been associated with insufficient sleep, particularly in adolescents. Some studies have found a link between reduced sleep and risk-taking behavior such as alcohol and drug use, tobacco use, sexual activity, and school truancy. Literature that supports an association between insufficient sleep and overweight/obesity is especially robust (although not completely unanimous). Although the literature consistently reports benefits from sufficient sleep, which may be achieved by implementing a later school start time, the studies have been conducted using a range of methodological approaches. The Department has highlighted some of the strengths and limitations of the literature in the body of the report.

Short sleep duration (less than six hours) is associated with subjective sleepiness while driving and significantly increased motor vehicle accidents, even controlling for a number of other clearly impactful variables, including alcohol and drug use, previous crash history and risky driving behaviors such as speeding.

Effects of Later School Start Times

Increased awareness of the sleep problems facing children and adolescents has driven national and local advocacy efforts to allow longer sleep times by delaying school start time. To date, over 100 schools and school districts in 43 states and the District of Columbia have implemented policies to begin school later, or have maintained a start time of 8:00 a.m. or later; the majority fall into the former category. The first U.S. schools to implement a later start time were in Edina, Minnesota, where change began nearly two decades ago in 1997. Of course, this list represents a small fraction of total U.S. schools, as evidenced by the fact that the mean national high school start time reported by the National Center for Education Statistics Schools and Staffing Survey has moved only five minutes, from 7:54 a.m. in the 2001-2002 academic year, to 7:59 a.m. in school year 2011-2012.

Additionally, a handful of schools and school districts in Canada, the United Kingdom, and South Korea have implemented later start times. Following later start times, schools in the U.S. and abroad have reported financial savings, improved academic achievement, improved mental and overall health, decreased motor vehicle accidents, and higher attendance and graduation rates. Increases in enrollment and attendance (including fewer tardy arrivals) have been noted in some schools where later start time has been implemented.

Students' subjective assessment of their own well-being is favorably affected: they report less daytime sleepiness and fatigue, greater motivation, and report better ability to stay awake while studying, taking tests or attending class. Objective parameters such as performance in a variety of school subjects, and in state and national achievement tests also show improvement. Notably, students were found to have lower

grades and more absences in their first period class than in other classes. It is also noted that poor performance in a first period math class may negatively impact performance in future math classes. Schools where start time is delayed may see a decrease in motor vehicle accident risk in surrounding neighborhoods, and in comparison to schools with earlier start times. A recent review of the effects of later start times noted a 65-70% reduction in motor vehicle crashes when school start times were delayed.

School Start Times, Sleep, and Student Outcomes

Prepared for Montgomery County Public Schools

October 2014



In the following report, Hanover Research examines the impact that school start times have on student achievement and other student outcomes. The report reviews literature on the effect of start times on academic achievement at the elementary, middle, and high school levels and introduces literature surrounding other student outcomes that may be impacted by changes to school start time. Hanover also provides additional information about the specific sleep needs and outcomes of sleep for elementary school-aged students.

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EXECUTIVE SUMMARY AND KEY FINDINGS

INTRODUCTION

The issue of school start times has received increased media attention as districts throughout the country consider delaying high school start times, often with the hope that students will receive more time to sleep in the mornings. In 2012, Montgomery County Public Schools (MCPS) convened a work group, The Bell Times Work Group, to examine the impact of adjusting school start times in the county. Through extensive research on adolescent sleep, the work group developed a series of schedule options for changing start times at all levels of schooling.

MCPS has tasked Hanover Research, a private research firm, to provide an exhaustive literature review on the association between school start times and student outcomes. This report serves as an independent review of the literature on school start times. The Bell Times Work Group published a report in October 2013 that included a literature review on the start times research since 1998. This external literature review examines many of the same peer-reviewed journal articles from the Bell Times Work Group Report due to the limited nature of the research base, with the addition of new research since the writing of the 2013 report.

This report examines student outcomes such as academic achievement and student well-being measures. In addition, MCPS requested a section on the unique sleep needs and sleep outcomes of elementary school-aged students. The literature base in this area is extremely limited, as most studies in this area focus on teens and adults. The report is divided into three sections:

- **Section I: School Start Time and Student Achievement** examines literature on school start times, comparing results of studies that suggest start times have positive, mixed, or no effect on student performance.
- **Section II: School Start Time and Other Student Outcomes** examines the research available on the effect that school start times may have on a variety of additional student outcomes, such as the amount of sleep, student mood, and car crash rates.
- **Section III: Sleep Needs of Elementary School Students** summarizes literature on the sleep needs of elementary school-aged students and investigates the relationship between sleep and various elementary student outcomes.

KEY FINDINGS

SCHOOL START TIMES AND ACHIEVEMENT OUTCOMES

- **The body of research on school start times does not provide conclusive evidence that start times impact student achievement.** The literature base demonstrates studies with various results (positive, mixed, and no effect) on academic measures that include standardized state test scores and grade point averages.

- **Studies that found a positive relationship between school start times and student achievement include students from elementary students up through college.** These studies also found that later start times were especially beneficial for low-performing students, and that start times even impacted performance in future subjects.
- **Other studies using data from Kansas, Minnesota, and Virginia found no such relationship between start times and achievement.** This result included a variety of student academic outcomes, such as grades, grade point average, and state assessments. Additionally, Hinrichs found no effect when looking for any differences in gender or poverty status.
- **Elementary school start times vary in their impact on student achievement.** One Kentucky study found early start times to negatively impact only elementary schools with lower levels of free/reduced lunch participants, while another study based in North Carolina found no effect on test scores.

SCHOOL START TIMES AND OTHER STUDENT OUTCOMES

- **Studies that examined start times on student sleep found that both middle and high school students slept more when their school start times were later.** Wahlstrom's 2002 study found that students went to sleep at the same time as before the change in start time, while Wolfson et al. found that students at the later starting high school went to sleep 22 minutes later.
- **As students received more sleep, feelings of sleepiness lessened while attention and feelings of alertness increased.** The extant literature states that even modest delays in start time improve measures of daytime sleepiness and fatigue. Some studies even reported improved behavior, reduced caffeine consumption, and better overall student moods following a delay in start time.
- **Start times were also found to improve rates of tardiness, although the impact on absences was mixed.** Some studies, such as Edwards, found absences declined when start times rose, while others, such as Hinrichs and Wahlstrom et al.'s 2014 study, found either no relationship or a mix of negative and positive results.
- **Teen car crash rates were found to greatly decrease when schools start later.** A study conducted by Danner and Phillips found that car crash rates were reduced in a Kentucky county after the high school implemented a delayed start time. An additional study by Vorona et al. compared the teen crash rate between two Virginia cities and found that the car crash rate among teens was significantly lower in the city with a later high school start time.

SLEEP NEEDS AND SLEEP OUTCOMES FOR ELEMENTARY SCHOOL-AGED STUDENTS

- **Elementary school students (ages 5 to 12 years) require 10 to 11 hours of sleep per night.** Student's habits and activities affect the amount and quality of sleep. For

example, increasing academic demands from school, sports and extracurricular commitments, and use of television, computers, and other devices can disrupt sleep and cause students to go to bed later.

- **Pre-adolescents are found to have early morning preferences, as compared to older children.** Although school-aged children begin to show signs of sleep phase preference (evening vs. morning type), researchers such as Carskadon found that younger children prefer earlier hours. The shift towards an evening preference usually occurs at adolescence when circadian patterns change.
- **The research on sleep outcomes for elementary school-aged children is very limited.** The majority of studies examine teens and adults, and much of the research that is available on young children occurs outside of the United States.
- **The limited studies that are available indicate that a lack of sleep has a negative impact on elementary-aged children.** The cognitive performance of young children is adversely affected by reductions in sleep, according to studies by Randazzo, et al. and Molfese. Additionally, long term physical health measures of children, such as obesity rates, were found to be associated with inadequate amounts of sleep.

SECTION I: SCHOOL START TIME AND STUDENT ACHIEVEMENT

A recent policy statement by the American Academy of Pediatrics has brought national attention to the issue of school start time. According to the policy statement, insufficient sleep and chronic sleep loss have become a public health epidemic among American adolescents, resulting in a host of academic, psychological, and health challenges. Some research suggests that later school start times might encourage healthier adolescent sleep patterns and lead to a variety of physical, mental, and social benefits.¹

While literature on school start time and adolescent sleep deprivation abounds, limited research highlights the relationship between school start time and student achievement. Few studies directly assess the impact of this association, instead focusing on the relationship between adolescent sleep patterns and student performance. In the following section, Hanover Research limits the scope of literature specifically to school start times and student achievement.

Our review of the extant literature yielded eight studies that examined the relationship between school start times and academic achievement at the elementary, middle, and high school levels. This report includes empirical studies that primarily focus on K-12 public education in the United States. In addition, Hanover categorizes the studies based on the statistical significance of the results. Hanover classifies the degree of each study's effect as "positive," "mixed," or "no" effect. Our classification of the studies' impact is as follows:

- **Positive effect:** Studies with positive effects found statistically significant results, indicating a positive relationship between school start time and student achievement outcomes.
- **Mixed effect:** Studies with mixed effects had statistically significant results that indicated both positive and negative effects of early school start time on student achievement outcomes.
- **No effect:** Studies with no effect did not find statistically significant results indicative of a relationship between school start time and student achievement.

The following figure presents the effect, student level, and achievement outcome measures used in the studies included in our review (see Figure 1.1).

¹ "School Start Times for Adolescents." American Academy of Pediatrics, 2014. p. 644, 646.
<http://pediatrics.aappublications.org/content/early/2014/08/19/peds.2014-1697.full.pdf+html>

Figure 1.1: Summary of School Start Times and Academic Achievement Literature

STUDY			LEVEL	ACADEMIC OUTCOME MEASURE	EFFECT
Author	Title	Year			
Carrell, et al. ²	A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents	2010	College freshmen	Grades	Positive effect
Cortes, Bricker, and Rohlf's ³	The Role of Specific Subjects in Education Production Functions: Evidence from Morning Classes in Chicago Public High Schools	2012	High school	Grades, standardized test scores	Positive effect for math, no effect for English*
Edwards, F. ⁴	Early to rise? The effect of daily start times on academic performance	2012	Elementary, middle, and high school	Standardized test scores	Positive effect for middle and high school, no effect for elementary school*
Keller, et al. ⁵	Earlier School Start Times as a Risk Factor for Poor School Performance: An Examination of Public Elementary Schools in the Commonwealth of Kentucky	2014	Elementary school	Standardized test scores	Positive effect
Wahlstrom, et al. ⁶	Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study	2014	High school	Grade point average, grades, standardized test scores	Mixed effect
Arlington Public Schools ⁷	Impact of 2001 Adjustments to High School and Middle School Start Times	2005	High school, middle school	Grades, grade point average	No effect

²Carrell, et al. "A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents." University of California at Davis, October 5, 2010. <http://www.econ.ucdavis.edu/faculty/scarrell/sleep.pdf>

³Cortes, K., J. Bricker, and C. Rohlf's. "The Role of Specific Subjects in Education Production Functions: Evidence from Morning Classes in Chicago Public High Schools." *The B.E. Journal of Economic Analysis & Policy*, 12:1, 2012. <http://users.nber.org/~cortesk/bejeap2012.pdf>

⁴Edwards, F. "Early to rise? The effect of daily start times on academic performance." *Economics of Education Review*, 31, 2012. <http://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>

⁵Keller, P., et al. "Earlier School Start Times as a Risk Factor for Poor School Performance: An Examination of Public Elementary Schools in the Commonwealth of Kentucky." *Journal of Educational Psychology*, June 16, 2014. <http://www.apa.org/pubs/journals/releases/edu-a0037195.pdf>

⁶Wahlstrom, et al. "Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Center for Applied Research and Educational Improvement, February 2014. <http://conservancy.umn.edu/bitstream/11299/162769/1/Impact%20of%20Later%20Start%20Time%20Final%20Report.pdf>

⁷"Impact of 2001 Adjustments to High School and Middle School Start Times." Arlington Public Schools, June 2005. <http://www.fcps.edu/fts/taskforce07/documents/arlington605.pdf>

STUDY			LEVEL	ACADEMIC OUTCOME MEASURE	EFFECT
Author	Title	Year			
Hinrichs, P. ⁸	When the Bell Tolls: The Effects of School Starting Times on Academic Achievement	2011	High school	Standardized test scores	No effect
Wahlstrom, K. ⁹	Changing Times: Findings From the First Longitudinal Study of Later High School Start Times	2002	High school	Grades	No effect

* These studies are classified as “positive” because they indicate a statistically significant relationship between school start times and academic achievement in at least one academic subject or school level, with no negative findings.

SCHOOL START TIMES

The issue of optimal school start time has been debated at the national and local levels for over a decade. A national survey administered by the National Center for Education Statistics in 2001 found that nearly half of middle schools start at or before 8:00 a.m., with fewer than 25 percent starting after 8:30 a.m. As for high schools, a 2005 survey found that more than 50 percent of high schools started before 8:00 a.m. Notably, a recent study of high schools in New York City found that 10 percent of schools started at or before 7:30 a.m. and more than 80 percent of schools started at or before 8:30 a.m.¹⁰

Several national and local initiatives have developed in support of later high school start times. In 2009, Rep. Zoe Lofgren of California proposed House Concurrent Resolution 176, known as the “Zzz’s to A’s Resolution,” which resolved to delay high school start times to after 9:00 a.m.¹¹ Rep. Lofgren is currently finalizing a bill requiring the Department of Education to commission a study on school start times and student outcomes such as health and student achievement, in order to provide school districts with recommendations.¹² Similarly, a multitude of local initiatives have caused districts across the country to adopt later start times. Arlington Public Schools, for instance, adjusted the schedules of its high schools to start and end 45 minutes later during the 2001-2002 school year.¹³ Fairfax County

⁸Hinrichs, P. “When the Bell Tolls: The Effects of School Starting Times on Academic Achievement.” *Education Finance and Policy*, 6:4, Fall 2011.

<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=https%3A%2F%2Fwww.aeaweb.org%2Faea%2F2011conference%2Fprogram%2Fretrieve.php%3Fpdfid%3D60&ei=hY0HVOqqC9WPNq2ugNAD&usg=AFQjCNF1E4L9oufa08F4UBKUpuiftkonjw&bvm=bv.74115972,d.eXY>

⁹Wahlstrom, K. “Changing Times: Findings From the First Longitudinal Study of Later High School Start Times.” *National Association of Secondary School Principals Bulletin*, 86:633, December 2002.

<http://teensneedsleep.files.wordpress.com/2011/04/wahlstrom-changing-times-findings-from-the-first-longitudinal-study-of-later-high-school-start-times.pdf>

¹⁰Jacob, B.A. and J.E. Rockoff. “Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments.” The Hamilton Project at the Brookings Institution, September 2011. p. 6.

¹¹“House Concurrent Resolution 176.” U.S. Government Printing Office. <http://www.gpo.gov/fdsys/pkg/BILLS-111hconres176ih/pdf/BILLS-111hconres176ih.pdf>

¹²Emma, C. “Which States are Making the Grade? – Congress Could Pass More Education Bills This Year – ‘Davids v. New York’ Heads to Court.” Politico Morning Education, September 11, 2014. http://www.politico.com/morningeducation/0914/morningeducation15258.html?ml=ae_1

¹³“Impact of 2001 Adjustments to High School and Middle School Start Times.” Op. cit., p. 1.

Public Schools in Fairfax County, Virginia is currently undertaking a similar review of its start times, considering four later start time options for its middle and high schools. The earliest option would delay high school start times to 8:00/8:10 a.m. with middle schools starting at 7:20 a.m., and the latest option would delay high school start times to 9:15 a.m. with middle schools starting at 8:20/8:30 a.m.¹⁴

According to a recent study by the Center for Applied Research and Educational Improvement at the University of Minnesota, more than 75 percent of high school students surveyed consider the ideal school start time to be 8:30 a.m. or later. More than 50 percent of students consider the ideal start time to be 9:00 a.m. or later. Figure 1.2 presents high school students' perceptions of ideal start times, based on a survey of high school students in Minnesota, Colorado, and Wyoming.

Figure 1.2: Students' Perceptions of Ideal Start Times

IDEAL START TIME	PERCENT OF RESPONDENTS
7:00 a.m.	3.2%
7:30 a.m.	5.1%
8:00 a.m.	16.3%
8:30 a.m.	24.8%
9:00 a.m.	35.8%
Later than 9:00 a.m.	14.8%

Source: Wahlstrom, et al.¹⁵

START TIMES AND STUDENT ACHIEVEMENT

Research on the relationship between school start times and student achievement is inconclusive, with different studies indicating positive, mixed, or no statistically significant result. We examine these studies in more depth below.

POSITIVE EFFECT

Several recent studies suggest that start time positively impacts academic performance. A 2012 study by economist Finley Edwards found that later start times improved the performance of middle school students on standardized tests in both reading and math.¹⁶ Using data from Wake County Public Schools in Wake County, North Carolina from 1999 to 2006, Edwards compared students grouped into two tiers: Tier I included students who attended middle schools that started between 7:30 a.m. to 7:45 a.m., and Tier II included students who attended middle schools that started between 8:00 a.m. to 8:45 a.m.¹⁷

¹⁴"Later Start Time Options." Fairfax County Public Schools. <http://www.fcps.edu/news/starttimes-options.shtml>

¹⁵Wahlstrom, et al., "Examining the Impact of Later School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Op. cit., p. 25.

¹⁶Edwards, F. "Early to rise? The effect of daily start times on academic performance." Op. cit., p. 970.

¹⁷Ibid., p. 974.

Edwards found that the effect of starting school one hour later was associated with an increase in standardized test scores by 1.8 percentile points in math and one percentile point in reading.¹⁸ Moreover, the benefits of later start times were pronounced for low-performing students: results indicated that effects were twice as large for students who scored in the bottom third of students than for those who scored in the top third of test-takers.¹⁹ Not only do the results of Edwards' study suggest that later start times benefit middle school students, he found that these results persisted into high school. When Edwards analyzed tenth grade comprehensive exams that measured growth in reading and math, he found that a one hour later start time in middle school was associated with a 2.0 and 1.6 percentile increase in high school math and reading, respectively.²⁰

Other empirical studies also found a relationship between start times and achievement for high school students. In a 2012 study of high schoolers from Chicago Public Schools, Cortes, Bricker, and Rohlfis evaluated the effects of first period classes on course grades and standardized test scores. They found that first period classes were associated with lower course grades and test scores.²¹ The effect of first-period courses was especially pronounced for certain student subgroups and academic subjects. The authors found that this effect "became greater as the amount of exposure increased over the course of the academic year for black students."²² Notably, math classes seem to impact other subject areas, in addition to having long term effects. Cortes and her colleagues found that first period math classes negatively affected reading test scores. Moreover, the study found that Algebra I courses were associated with lower grades in Algebra II in later years.²³ The authors recommend that "math classes for at-risk students should be scheduled after first period and that math teachers' preparation time should be scheduled during first period."²⁴

A 2010 study by Carrell, et al. on the impact of first period classes on the course grades of first-year students at the United States Air Force Academy (USAFA) provides perhaps "the strongest evidence" on the relationship between start times and academic outcomes.²⁵ The study found "a positive causal relationship between start time and academic performance for the students at USAFA," with earlier course times negatively affecting students' course grades.²⁶ Not only did these students perform worse in their first period classes, they performed worse in all of their courses.²⁷ The researchers found that the negative effects diminished as start times were moved later, from 7:00 a.m. to 7:50 a.m.²⁸

¹⁸ Edwards, F. "Early to Rise? The Effect of Daily Start Times on Academic Performance" Op. Cit.

¹⁹ Ibid.

²⁰ Ibid., p.982.

²¹ Cortes, K., J. Bricker, and C. Rohlfis., Op. Cit., p. 2.

²² Ibid., p. 22.

²³ Ibid., p. 30.

²⁴ Ibid., p. 32.

²⁵ Jacob, B. and J. Rockoff., Op. Cit., p.8.

²⁶ Carrell, et al., Op. cit., p. 13.

²⁷ Carrell, et al., Op Cit., p. 16

²⁸ Ibid., p. 12.

Although this study examined the behavior of high-achieving college students, Carrell et al. contend that their results are generalizable to high school students, as first semester college students are adolescents that have the same sleep patterns as high school-aged teens. Moreover, the authors suggest that their use of the USAFA sample, an elite group of high-achieving students with a preference for a regimented lifestyle, provides even stronger evidence for the adverse effects of early start times. If the elite USAFA students' performance was negatively impacted by early start times, it is likely that early start times would particularly affect the performance of average students.²⁹

MIXED EFFECT

A multi-site study conducted by Wahlstrom and her colleagues at the University of Minnesota found varying results when evaluating the effects of later high school start times on the academic performance of students in Minnesota, Colorado, and Wyoming.³⁰ Specifically, the study evaluated the academic performance of 9,000 high school students across eight high schools in five school districts after schools delayed start times.³¹ In their analysis of students' mean grade point average (GPA) of core subject area courses or grades by individual course,³² Wahlstrom et al. found that many of their sampled high schools saw increases in grades; however, Mahtomedi, Saint Louis Park, and South County experienced both increases and decreases in grades (see Figure 1.3).³³ Although the authors of the study concluded that "there are empirically-based positive outcomes for adolescents whenever the start time of their high school is moved to a later time,"³⁴ not all outcomes were shown to be positive. Wahlstrom and her colleagues found that an analysis of standardized achievement tests (based on state standardized test scores or the composite ACT or PLAN) followed "[n]o consistent patterns."³⁵ Results indicated most test scores had no significant differences, although the few subject areas that did show statistical significance varied in the direction of the relationship.³⁶

²⁹ Ibid., p. 2.

³⁰ Wahlstrom, et al., "Examining the Impact of Later School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Op. cit., pp. 8-10.

³¹ Ibid., p. 2. Note: data for the three participating South Washington County high schools were combined.

³² These authors examined total GPA of math, English, social studies, and science in 1st or 3rd period classes for all schools except for Mahtomedi and South Washington County high schools. For these schools, the authors were able to examine grades by course.

³³ Wahlstrom, et al., "Examining the Impact of Later School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Op. cit.

³⁴ Ibid., p. 52.

³⁵ Ibid., p. 41.

³⁶ Ibid., p. 41.

Figure 1.3: Change in Mean GPA for 1st or 3rd Period Core Courses After Delayed Start Time

GRADE LEVEL	HIGH SCHOOL/DISTRICT					
	FAIRVIEW	BOULDER	MAHOMETI	SAINT LOUIS PARK	SOUTH WASHINGTON COUNTY	JACKSON HOLE
All grades	Increase	Increase	Increase, Decrease	ns	Increase, Decrease	Increase
Grade 9	Increase	n/a	Increase, Decrease	n/a	n/a	Increase
Grade 10	ns	n/a	Increase, Decrease	n/a	Increase	Increase
Grade 11	Increase	n/a	Increase, Decrease	n/a	Increase	Increase
Grade 12	Increase	n/a	Increase, Decrease	n/a	Increase	Increase

Source: Wahlstrom et al.³⁷

Note: "Increase" indicates statistically significant increases in grade point average (GPA). "Increase, Decrease" indicates that the results were mixed: some GPAs increased, while others decreased. "n/a" means the analysis could not be completed. "ns" means that the results were statistically non-significant.

NO EFFECT

Despite the body of evidence that suggests that later school start times positively affect student achievement, a countervailing body of evidence suggests that start times have no impact on student achievement. In a study published in 2011, educational economist Peter Hinrichs evaluated the impact of high school start times on student achievement in two Minnesota districts, Minneapolis Public Schools (MPS) and St. Paul Public Schools. He compared the ACT test scores of students at St. Paul Public Schools, which started the school day at 7:30 a.m., to those of students in Minneapolis Public Schools, which adopted a later start time of 8:40 a.m. in 1997-1998.³⁸ He found no differences in ACT scores for districts that moved their start times later, compared to districts that kept the earlier start times.

Hinrichs also evaluated a broader sample of data from high schools in Kansas and Virginia to estimate the effects of start time on students' performance on standardized tests.³⁹ The analysis in Kansas was based on state testing data provided by the Kansas Department of Education. The use of these data avoided the selection bias that is present in using ACT scores. The results from Kansas supported his findings from Minnesota – he found no effect of school start time on test scores in reading, math, social studies, and science. He also found no effect when segmenting the data by gender or free/reduced lunch status. Hinrichs notes that he estimated a similar analysis on Virginia data, and these results corroborated the Kansas and Minnesota results.

³⁷Ibid., p. 40.

³⁸Hinrichs, P. Op. cit.

³⁹Ibid.

Arlington Public Schools (APS) examined a change to their high school start time to 8:15 a.m. in 2001. Concurrently, APS moved the middle school start time 20 minutes earlier than their previous start time, due to limited availability in buses and bus drivers.⁴⁰ APS found slight positive changes to grade point averages in the high school, and mixed results in the middle schools; however, these changes were “so slight that it did not represent a change in letter grades for the students.”⁴¹ In other words, the effect of school time changes made no significant impact on student grades.⁴²

Hinrichs proposes the following reasons why school start time may not impact students’ performance on standardized tests:⁴³

- While early start times may cause students to lose sleep and learn less per unit of time, they may learn more outside of school by being awake longer.
- Students may be able to adapt to early times by re-optimizing sleep patterns, such as catching up on sleep over the weekend.
- Students may adapt to early schedules with environmental and chemical stimulation, such as caffeine.
- Though students’ biological clocks may lead them to perform better later in the day, teachers may perform better earlier in the day, having a counteracting effect.
- Later start times could result in less time spent with parents in the morning, without affecting the amount of time spent with parents in the afternoon or evening.
- Before-school activities might nullify the effects of later start times.
- With later start times, students may miss instructional time in the afternoon due to early dismissal for athletic and extracurricular activities.

Nevertheless, Hinrichs’ findings of “no effect” corroborate research conducted by Wahlstrom in 2002. Wahlstrom evaluated data from Minneapolis Public Schools after the district changed the start time of seven high schools to 8:40 a.m.⁴⁴ Analyzing students’ letter grades in classes three years before and three years after the change, Wahlstrom identified an upward trend, but no statistically significant differences in students’ grades as a result of the later start time.⁴⁵ The study did not consider SAT and ACT test scores as a student achievement measure because students who take such exams tend to academically gifted, resulting in overall higher scores.⁴⁶ Wahlstrom also highlighted the limitations of using grades as a measure of student achievement, as “grading is often a subjective action by teachers.”⁴⁷ While evidence indicated that start times do not influence academic outcomes,

⁴⁰ Arlington County Public Schools. Op. Cit., p. 1.

⁴¹ Arlington County Public Schools. Op Cit., p. 19.

⁴² Arlington County Public Schools. Op. cit., pp. 7-11.

⁴³ Bulleted points adapted from: Hinrichs, P. Op. cit., pp. 15-16.

⁴⁴ Wahlstrom, K. “Changing Times: Findings From the First Longitudinal Study of Later High School Start Times.” Op. cit., p. 4.

⁴⁵ Ibid., p. 11.

⁴⁶ Ibid., p. 12.

⁴⁷ Ibid., p. 11.

Wahlstrom’s results suggested that later start times have non-academic benefits, such as improving student attendance rates for students who were not continuously enrolled for two consecutive years in the same high school.⁴⁸ Such non-academic benefits could have “spillover” effects that lead to improvements in academic performance.

ELEMENTARY SCHOOL START TIMES AND ACHIEVEMENT

Although most literature on school start times focuses on adolescents, a small body of research suggests that school start times impact the academic performance of elementary school students. Keller et al. evaluated the effects of school start times on the test scores of elementary students on the Kentucky Performance Rating for Educational Progress (K-PREP) assessment.⁴⁹ Although schools that started earlier were associated with lower test scores, these results were only found in middle and upper class elementary schools.⁵⁰ While this finding was unexpected to the study’s authors, they attributed students’ poorer academic performance to the “physical, behavioral, and psychological ramifications of sleep deprivation.”⁵¹

In contrast to Keller et al.’s findings, in his study of the Wake County Public School System (described previously in this section), Edwards found that school start times had no effect on elementary student achievement. Specifically, Edwards examined the impact of start times on students’ math and reading test scores and found no relationship.⁵² However, Edwards cautions that since the sampled elementary schools started at 8:15 a.m. or 9:15 a.m., it is unclear whether the start times had no effect on elementary school-aged students or that elementary school start times were not early enough to show an impact in this analysis.⁵³

LIMITATIONS OF RESEARCH ON START TIMES AND ACHIEVEMENT

Several limitations exist in the literature of school start times and academic achievement that may skew or limit the generalizability of the results. First, the methodology used in studies on school start times limits the ability to provide causal evidence. Most studies are correlational in nature and are thus unable to provide empirical proof that changes in start times result in differences in student achievement.⁵⁴ According to Dr. Joseph Buckhalt, Director of the School Psychology Program at Auburn University, research using experimental designs would provide the best evidence of a relationship between start times and academic achievement, though such studies would be subject to multiple practical and technical difficulties.⁵⁵

⁴⁸Ibid., p. 8.

⁴⁹Keller, et al., Op. cit., p. 2.

⁵⁰Ibid., p. 6.

⁵¹Keller, et al., Op. cit., p. 6.

⁵²Edwards, F. “Early to rise? The effect of daily start times on academic performance.” Op. cit., p. 980.

⁵³Ibid., p. 981.

⁵⁴Carrell, et al., Op. cit., p. 2.

⁵⁵Buckhalt, J.A. “School Year Means Sleep Challenges for Kids of All Ages.” American Psychological Association, August 27, 2012. <http://www.apa.org/news/press/releases/2012/08/sleep-challenges.aspx>

Next, the variables used in start time studies can limit their impact. As Carrell et al. observe in their investigation of the effects of start times on students at the U.S. Air Force Academy, certain academic achievement measures may yield inaccurate or misleading results. For instance, the use of grades as a student achievement metric may be ineffective due to “heterogeneity of assignments and exams as well as the subjectivity of assigning grades to assessments across instructors.”⁵⁶ Similarly, the use of student scores on standardized tests such as the ACT is subject to selection bias, as students who register to take such exams tend to be high-performing, causing skewed results.⁵⁷ Other confounding factors, such as self-selection of schedules and the effects of instructors could influence the results of a school start time study.⁵⁸ Finally, as Keller et al. observe, research on school start times tend to focus on one school or district, making it difficult to estimate the widespread impact of start times on student achievement. Similarly, start time research often fails to address the differences in school and student characteristics. Keller et al. recommends future research to examine start times with consideration to socioeconomic and demographic characteristics.⁵⁹

⁵⁶Carrell, et al., Op. cit., p. 2.

⁵⁷Wahlstrom, K. “Changing Times: Findings From the First Longitudinal Study of Later High School Start Times.” Op. cit., p. 12.

⁵⁸Carrell, et al., Op. cit., p. 2.

⁵⁹Keller, et al., Op. cit., p. 2.

SECTION II: START TIME AND OTHER STUDENT OUTCOMES

In addition to academic outcomes due to school start times, studies have indicated numerous other non-academic outcomes that accompany changes to a school's starting time. This section of the report provides an overview of the research literature that examines the more expansive impact of changes to school start times, including student well-being measures.

The following figure presents an overview of the studies that are included in this section, including the title, year of publication, school level, and the effect of the specific outcome measures. As with the literature reviewed in Section I, we limit the scope of studies to research focused on K-12 public education in the United States. We use the same classification on the degree of each study's effect as "positive," "mixed," or "no" effect.

Figure 2.1: Summary of School Start Times and Other Student Outcomes Literature

STUDY			LEVEL	OTHER OUTCOME MEASURE	EFFECT
AUTHOR	TITLE	YEAR			
Arlington Public Schools ⁶⁰	Impact of 2001 Adjustments to High School and Middle School Start Times	2005	High school, middle school	School attendance, attentiveness, extracurriculars	No effect for attendance, positive effect for attentiveness, positive effect for extracurriculars
Boergers, et al. ⁶¹	Later School Start Time is Associated with Improved Sleep and Daytime Functioning in Adolescents	2013	High school	Sleep, mood, homework, athletics/extracurriculars	Positive effect for sleep, positive effect for mood, no effect for homework, no effect for athletics/extracurriculars
Danner, F. & B. Phillips ⁶²	Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes	2008	High school, middle school	Sleep, teen car crash rates	Positive effect for sleep, positive effect for crash rates
Edwards, F. ⁶³	Early to Rise? The Effect of Daily Start Times on Academic Performance	2012	Elementary, middle, and high school	Attendance, time spent on homework, time spent watching television	Positive effect for attendance, positive effect for homework, positive effect for time watching television
Hinrichs, P. ⁶⁴	When the Bell Tolls: The Effects of School Starting Times on Academic Achievement	2011	High school	School attendance	No effect for attendance
Owens, J., et al. ⁶⁵	Impact of Delaying School Start Time on Adolescent Sleep, Mood, and Behavior	2010	High school	Sleep, mood and behavior	Positive effect for sleep, positive effect for mood and behavior

⁶⁰ "Impact of 2001 Adjustments to High School and Middle School Start Times." Arlington Public Schools, June 2005. <http://www.fcps.edu/fts/taskforce07/documents/arlington605.pdf>

⁶¹ Boergers, J., C. Gable, and J. Owens. "Later School Start Time is Associated with Improved Sleep and Daytime Functioning in Adolescents." *Journal of Developmental & Behavioral Pediatrics*. 2013. <http://www.gwern.net/docs/melatonin/2014-boergers.pdf>

⁶² Danner, F. and B. Phillips. "Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes." National Center for Biotechnology Information. 2008. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2603528/#B14>

⁶³ Edwards, F. "Early to Rise? The Effect of Daily Start Times on Academic Performance." *Economics of Education Review*, 31, 2012. <http://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>

⁶⁴ Hinrichs, P. "When the Bell Tolls: The Effects of School Starting Times on Academic Achievement." *Education Finance and Policy*, 6:4, Fall 2011. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFJAA&url=https%3A%2F%2Fwww.aeaweb.org%2Ffaea%2F2011conference%2Fprogram%2Fretrieve.php%3Fpdfid%3D60&ei=hY0HVQqqC9WPNq2ugNAD&usg=AFQjCNF1E4L9oufa08F4UBKUpuiftkonjw&bvm=bv.74115972,d.eXY>

⁶⁵ Owens, J. et al. "Impact of Delaying School Start Time on Adolescent Sleep, Mood, and Behavior." *The Journal of the American Medical Association*. 2010. <http://archpedi.jamanetwork.com/article.aspx?articleid=383436>

STUDY			LEVEL	OTHER OUTCOME MEASURE	EFFECT
AUTHOR	TITLE	YEAR			
Vorona, R., et al. ⁶⁶	Dissimilar Teen Crash Rates in Two Neighboring Southeastern Virginia Cities with Different High School Start Times	2011	High school	Teen car crash rates	Positive effect for crash rates
Wahlstrom, K. ⁶⁷	Changing Times: Findings from the First Longitudinal Study of Later High School Start Times	2002	High school	Sleep, school attendance, attentiveness, mood and behavior, extracurriculars	Positive effect for sleep, mixed effect for attendance, positive effect for attentiveness, positive effect for mood and behavior, no effect for extracurriculars
Wahlstrom, K., et al. ⁶⁸	Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study	2014	High school	Sleep, school attendance, tardiness, teen car crash rates	Positive effect for sleep, mixed effect for attendance, positive effect for tardiness, mixed effect for crash rates
Wolfson, A., et al. ⁶⁹	Middle School Start Times: The Importance of a Good Night's Sleep for Young Adolescents	2007	Middle school	Sleep, attendance, tardiness	Positive effect for sleep, no effect for attendance, positive effect for tardiness

⁶⁶ Vorona, R., M. Szklo-Coxe, A. Wu, M. Dubik, Y. Zhao, and J. Ware. "Dissimilar Teen Crash Rates in Two Neighboring Southeastern Virginia Cities with Different High School Start Times." National Center for Biotechnology Information. 2011. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3077341/>

⁶⁷ Wahlstrom, K. "Changing Times: Findings from the First Longitudinal Study of Later High School Start Times." *National Association of Secondary School Principals Bulletin*, 86:633, December 2002. <http://www.cehd.umn.edu/carei/publications/documents/Bulletin200212Wahlstrom.pdf>

⁶⁸ Wahlstrom, K. et al. "Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Center for Applied Research and Educational Improvement, February 2014. <http://conservancy.umn.edu/bitstream/handle/11299/162769/Impact%20of%20Later%20Start%20Time%20Final%20Report.pdf?sequence=1&isAllowed=y>

⁶⁹ Wolfson, A., Spaulding, C. Dandrow, and E. Baroni. "Middle School Start Times: The Importance of a Good Night's Sleep for Young Adolescents." 2007. <http://www.ncbi.nlm.nih.gov/pubmed/17680731>

START TIMES AND SLEEP

The majority of the literature indicated that later school start times often resulted in more sleep for students.⁷⁰ Some studies suggested that students received more sleep because students' bed times remained the same after schools began later in the morning. Other studies found that bed times did shift, both earlier and later in the evening, but students still received more sleep than before a shift to a later start time.

A recent study conducted by Boergers, Gable, and Owens surveyed 197 students at a coeducational New England boarding school to determine the impact of a delay in school start time on Grade 9 through 12 students, and students at the post-graduate level. The researchers administered a survey to students in the fall semester when the school day began at 8:00 a.m. and surveyed the same students again in the winter semester after the start time was changed to 8:25 a.m. The survey asked the students about their sleep-wake behaviors, how well they functioned during the day, what activities they participated in, and other health related questions. The study found that students' bedtimes did not shift later after the start time change, and that students were receiving more sleep. In fact, the percentage of students receiving eight or more hours of sleep each night increased from 18 percent to 44 percent after the 25-minute delay. The authors also found that students who received less than eight hours of sleep in the fall (prior to the time change), and Grade 9 and 10 students were most likely to sleep longer after a start time delay. The findings also cited a significant decrease in the signs of daytime sleepiness, including falling asleep in class and tardiness. It is important to note that even after the delay, only 8.8 percent of students reported getting the recommended nine or more hours of sleep per night.⁷¹

A similar study conducted in 2010 by Owens et al. at a high school in Rhode Island involved 201 high school students in Grades 9 to 12. The research aimed to gauge the impact of a 30-minute delay in school start time on adolescents' sleep, mood, and behavior. The student participants were administered the Sleep Habits Survey before and after the change in school start from 8:00 a.m. to 8:30 a.m. After the time change, the average amount of sleep on a school night among students increased by 45 minutes, not only due to students waking up later in the day, but due to students heading to bed earlier. The authors found, through anecdotal comments, that the "perceived benefits of additional sleep motivated students to further modify their sleep-wake behaviors to optimize sleep duration."⁷² In addition, the percentage of students that were getting at least eight hours of sleep increased from 16.4 percent to 54.7 percent, and students also experienced more sleep satisfaction. The reports of sleep satisfaction were evidenced in the reduction of daytime sleepiness behavior like fatigue and tiredness. Similar to Boergers, Gable, and Owens, the authors of this study found that Grade 9 and 10 students received more sleep on school nights than upperclassman. This difference was almost 40 minutes between freshman and seniors in

⁷⁰ Wolfson, A., N. Spaulding, C. Dandrow, and E. Baroni. "Middle school start times: the importance of a good night's sleep for young adolescents." Op. cit.

⁷¹ Boergers, J., C. Gable, and J. Owens, Op cit., pp. 14-15.

⁷² Owens et al., Op. cit., p. 613.

this study. The study also found substantial variability between sleep patterns on the weekend compared to those during the week that was likely caused by students trying to compensate for their lack of sleep during the week.⁷³

Research on younger adolescents yielded similar findings. A 2007 study by Wolfson et al. focused on 205 middle school students in two urban, public middle schools in New England. One middle school (School E) started early at 7:15 a.m., while another school (School L) began at 8:37 a.m. (both schools began around 8:00 a.m. the year prior). Although students in the late-starting school reported waking up over an hour later than students in the early starting school, students in School L also went to sleep 22 minutes later.⁷⁴ This is contrary to Boergers et al. and Wahlstrom's 2002 study. In this study, Wahlstrom found that students continued to go to sleep at the same time after the start times shifted to later in the morning. This study found that students slept an additional hour longer than their early starting peers.⁷⁵

In their examination of high school students in Minnesota, Colorado, and Wyoming, Wahlstrom et al. (described in detail in Section I) found that the proportion of students receiving eight or more hours of sleep increased as school start times became later. Specifically, only 34 to 44 percent of students attending a school that started early (around 7:30 a.m.) received eight or more hours of sleep, compared to 57 to 66 percent of students that attended a school that started after 8:30 a.m. Interestingly, Wahlstrom and her colleagues also found that students who had a phone or computer in their bedrooms were more likely to get less than eight hours of sleep as compared to students who did not have these items in their rooms.⁷⁶

Research conducted by Danner and Phillips evaluated 9,966 students in Grades 6 to 12 within a large Kentucky county. The study began in Year 1 (1998) with a questionnaire that asked students specific questions about their sleep habits on school nights compared to non-school nights. The Year 1 survey respondents included approximately 66.9 percent of all middle and high school students enrolled in the county. The same survey was administered again one year later after the high school and middle school start times were changed from 7:30 to 8:30 a.m. and from 8:00 to 9:00 a.m., respectively. Through the analysis of responses to the questionnaires, Danner and Phillips found that the average hours of nightly sleep among adolescents increased while the amount of catch-up sleep on the weekends decreased.⁷⁷ The graphs in Figures 2.2 and Figures 2.3 illustrate the changes in sleep patterns after the hour change in start time.

⁷³ Ibid.

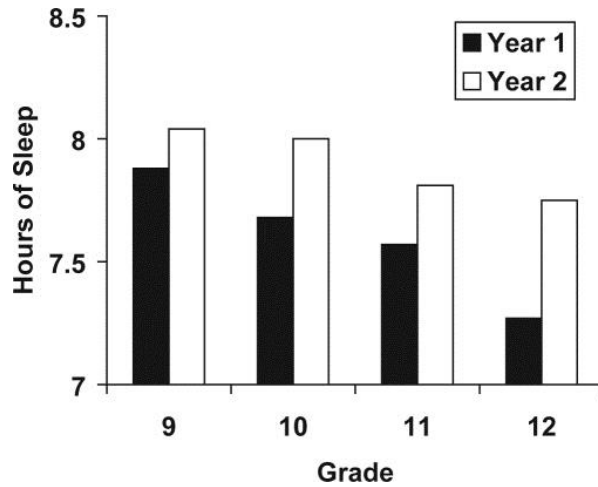
⁷⁴ Wolfson, A., N. Spaulding, C. Dandrow, and E. Baroni, Op. cit.

⁷⁵ Wahlstrom, K., "Changing Times: Findings from the First Longitudinal Study of Later High School Start Times," Op. Cit. p. 12

⁷⁶ Wahlstrom et al., "Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study," Op. cit.

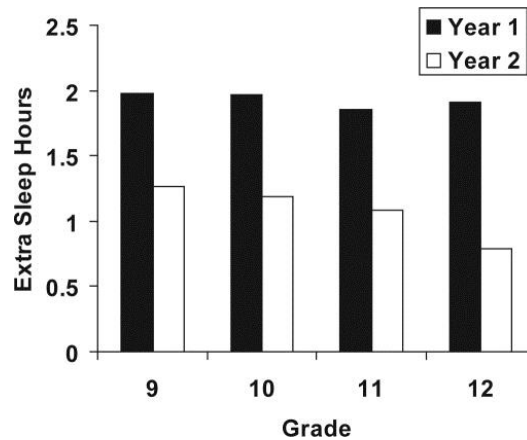
⁷⁷ Danner, F. and B. Phillips. "Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes," Op. cit.

Figure 2.2: Changes in Hours of Sleep in Year 1 vs. Year 2



Source: Danner and Phillips⁷⁸

Figure 2.3: Changes in Catch-Up Sleep in Year 1 vs. Year 2



Source: Danner and Phillips⁷⁹

ATTENDANCE AND TARDINESS

Several studies have aimed to understand the impact that delayed start times have on school attendance and tardiness. In many instances, the researchers hypothesize that later start times will lead to an increase in attendance and a decrease in tardiness. The results of the existing research literature are somewhat mixed, however.

⁷⁸ Ibid.

⁷⁹ Ibid.

The 2002 Wahlstrom study on the Minneapolis Public School District highlighted in the previous section not only examined the impact of start times on achievement, but also student attendance rates. Wahlstrom evaluated attendance data for the two years prior to the start time change and for three years after the start time delay; the start times were 7:15 a.m. and 8:40 a.m., respectively. The attendance analysis included 50,962 high school students in Grades 9 to 12 from seven Minneapolis high schools.⁸⁰

Students in this study were divided into two subgroups based on their enrollment status. Those students that were continuously enrolled in the same high school for two or more years were in one group and students who made frequent moves into and out of multiple schools were categorized as discontinuous. The study did not find any significant changes in attendance rates after the start time delay for those students classified as continuously enrolled, but did find noteworthy differences in the average attendance rates for students that were discontinuously enrolled. The average attendance rates for discontinuously enrolled students in Grades 9 to 11 increased significantly after the later start time was implemented. The attendance changes for seniors in both groups varied and were not significantly different after the delayed start time. Wahlstrom hypothesized that this might be due to the fact that those students who remained in school until the Twelfth Grade were committed to finishing their degree regardless of the school start time, as they could have legally withdrawn from school at that age. When she examined attendance by ethnicity, she found that attendance rose for Asian, Hispanic, Black and White students in Grades 9 to 11. No differences were found among ethnic groups for students in Grade 12.⁸¹ The average attendance rates before and after the change for all grade levels and both groups are included in Figure 2.4.

Figure 2.4: Percentage of Average Attendance Rates

PERIOD	GRADE 9		GRADE 10		GRADE 11		GRADE 12	
	Cont.	Disc.	Cont.	Disc.	Cont.	Disc.	Cont.	Disc.
Pre-Start Time Change								
1995-1997	93%	72%	95%	76%	93%	72%	93%	88%
Post-Start Time Change								
1997-1999	94%	76%	95%	78%	94%	78%	91%	89%
1998-2000	94%	75%	94%	78%	94%	77%	89%	89%

Source: Wahlstrom⁸²

In the 2014 Wahlstrom et al. study, the researchers examined high school attendance rates along with a host of other student outcomes. These researchers found some statistically significant increases in rates of attendance when comparing students in the same grade level pre- and post-delay, although many of these results were non-significant. Interestingly, when comparing the same students from year to year, however, rates of attendance actually decreased. The authors had no explanation for this decrease and suggested the

⁸⁰ "Wahlstrom, K. "Changing Times: Findings From the First Longitudinal Study of Later High School Start Times." Op. cit.

⁸¹ Ibid.

⁸² Ibid. p. 9.

need for additional research on this finding. Although attendance rates were inconsistent in the study, the majority of schools involved saw some reduction in tardiness overall, and the schools with the greatest time delays tended to have the largest decline in tardiness.⁸³

Wolfson et al. also examined attendance and tardiness in two middle schools in New England. Their study's results were consistent with Wahlstrom et al.'s 2014 study: Wolfson et al. found no differences in absences, but tardiness was almost four times as much in early starting schools than in the late starting schools.⁸⁴ Hinrichs' analysis on high schools in Minnesota also found no evidence of changes in attendance due to school start times.⁸⁵

Contrary to these findings, Edwards, in this study on middle schools in North Carolina, found that students who start school one hour later have 1.3 fewer absences during the school year. He suggests that the increase in absences may explain any differences in test scores.⁸⁶

Lastly, Arlington Public Schools found that regardless of start time, student attendance rates tended to decrease as students age. For all middle school and high school cohorts examined, the attendance rate of the students fell as grade level increased, even after the change in start times. Based on their findings, Arlington Public Schools reported that student maturity appears to have a larger impact on attendance rates than school start time.⁸⁷

ATTENTIVENESS, MOOD AND BEHAVIOR

There is a multitude of research that focuses on the impact of school starting times on cognitive performance in attention and concentration. Researchers have also examined the effect that sleep has on students' mood and behavior in school. The studies included below find that start times had a positive impact in these areas, due to the increased amount of sleep that students' received.

The Arlington Public Schools (APS) study measured the attentiveness of middle school and high school students before and after changes in school start time. Recall that while high schools started 45 minutes later, middle school students' start times were 20 minutes earlier than the previous start time. A survey was administered to participating students which asked them a series of questions on whether they were ready to start school, were alert during first period, were prepared for first period, and participated in class discussions during first period. A similar survey was also administered to teachers to gauge their perception of their students' attentiveness. Over 230 Eleventh Graders and 255 Eighth Grade students completed the student survey, while 232 high school and 179 middle school teachers completed the teacher survey.⁸⁸

⁸³ Wahlstrom et al., "Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study," Op. cit.

⁸⁴ Wolfson, A., N. Spaulding, C. Dandrow, and E. Baroni, Op. cit.

⁸⁵ Hinrichs, P. "When the Bell Tolls: The Effects of School Starting Times on Academic Achievement." Op. cit. p. 11.

⁸⁶ Edwards, Op. cit.

⁸⁷ "Impact of 2001 Adjustments to High School and Middle School Start Times." Op. cit. p. 12-13.

⁸⁸ Ibid., p. 13-19.

APS found that the responses from high school students did not substantially change after the delay in start times, although the percentage of high school students that participated in class discussions “all of the time” increased from 31 percent to 42 percent. Middle school student results were skewed in the opposite direction. Whereas seven percent of middle school students felt ready to start school “none of the time” before the time change, when start times were moved to earlier in the morning, 19 percent of middle schoolers felt ready “none of the time.” The authors attribute these results as a possible “reflection of their dissatisfaction with the change in start times.”⁸⁹ See Figure 2.5.

Figure 2.5: Percent Student Response on Attentiveness

QUESTION	ALL OF THE TIME		SOME OF THE TIME		NONE OF THE TIME		NO RESPONSE	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
High School Students								
Ready to start school	20%	18%	52%	63%	22%	18%	7%	1%
Alert during first period	22%	20%	52%	64%	18%	16%	8%	1%
Prepared for first period	41%	47%	46%	49%	6%	4%	7%	1%
Participated in class discussions during first period	31%	42%	52%	47%	10%	9%	7%	1%
Middle School Students								
Ready to start school	35%	20%	51%	55%	7%	19%	7%	7%
Alert during first period	31%	14%	50%	63%	12%	17%	7%	6%
Prepared for first period	62%	53%	30%	40%	2%	2%	7%	5%
Participated in class discussions during first period	44%	35%	46%	55%	4%	5%	6%	6%

Source: Arlington Public Schools⁹⁰

Note: After the start time change, high schools started later while middle schools started earlier than previous years.

As for teacher perceptions (Figure 2.6), more high school teachers “strongly agreed” and “agreed” that their students’ were alert, prepared, and participated during first period after the later time change. The middle school teacher responses were less favorable, and mimicked the student responses. Middle school teachers reported that students were neither as alert nor prepared after school started earlier in the day. Teachers also noticed a decline in class participation.⁹¹

⁸⁹ Ibid., p. 15

⁹⁰ Ibid., pp. 15-16

⁹¹ Ibid., pp. 16-18.

Figure 2.6: Percent Teacher Response on Student Attentiveness

QUESTION	STRONGLY AGREE		AGREE		DISAGREE		STRONGLY DISAGREE		NO OPINION		NO RESPONSE	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
High School Teachers												
Alert during first period	1%	12%	25%	41%	38%	17%	9%	11%	22%	24%	6%	5%
Prepared for first period	3%	10%	34%	41%	28%	20%	6%	8%	23%	16%	6%	6%
Participated in class discussions during first period	3%	13%	43%	47%	17%	14%	5%	4%	24%	15%	7%	7%
Middle School Teachers												
Alert during first period	10%	11%	50%	35%	11%	17%	3%	18%	25%	16%	1%	3%
Prepared for first period	8%	5%	55%	46%	10%	31%	1%	8%	26%	18%	1%	1%
Participated in class discussions during first period	10%	10%	58%	50%	7%	16%	0%	7%	24%	17%	2%	1%

Source: Arlington Public Schools⁹²

Note: After the start time change, high schools started later while middle schools started earlier than previous years.

The 2002 Wahlstrom et al. study conducted a survey with teachers to evaluate the changes in students that staff members noticed after the start time delay was implemented. More than half of teachers reported more students being alert during the first two periods of the school day than when school started earlier. These authors also found that the majority of high school principals indicated (through interviews) that they observed a change in the mood of students overall. Generally, the principals reported that the hallways during passing periods and the cafeteria during lunch were calmer than before the change. Five out of eight principals stated that they were dealing with less disciplinary referrals as well. The school counselors and nurses that were interviewed also conveyed similar feelings about students' calmer dispositions. Moreover, the counselors reported that fewer students were coming to them about relationship problems with their peers and/or parents. Urban and suburban parents were interviewed about the start time change as well, and although there were complaints surrounding the inconvenience that the start time posed for scheduling and transportation, the majority of parents claimed that their high school children were "easier to live with."⁹³

⁹² Ibid.

⁹³ Wahlstrom, K. "Changing Times: Findings from the First Longitudinal Study of Later High School Times." Op. cit. pp. 16-18.

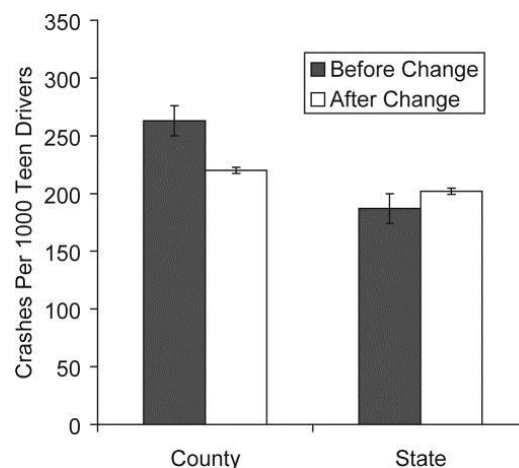
Boergers et al. also examined changes in students' mood before and after a 25-minute delay in start time in a coeducational boarding school. Boergers et al. found that before and after the delay, inadequate sleep was associated with greater levels of depression, sleepiness, and caffeine consumption; however, after the change in start time, the student outcomes in each of these areas improved significantly as more students reported longer durations of sleep.⁹⁴

START TIMES AND CAR ACCIDENTS

In addition to individual student outcomes, researchers have investigated the impact of school starting times on car crash rates in their communities. The majority of studies find a decrease in car accidents when schools start later in the day, however one district in Minneapolis saw a small increase in teen car crashes.

Danner and Phillips' study of one school district in Kentucky examined rates of motor vehicle crashes among 17 and 18 year olds before and after the high school start time change. Crash rates were computed for both the county and the entire state of Kentucky (excluding the county's data) and were calculated for the two years before the school district changed its start time and for the two years after the change. The rates of crashes in the county decreased following the change in school start time, even with rapid population growth in the area. Specifically, the county's crash rates decreased 16.5 percent, whereas other areas of the state increased 7.8 percent in crashes during the same time period.⁹⁵ Figure 2.7 compares the state and county crash rates before and after the start time change.

Figure 2.7: State and County Crash Rates in Year 1 vs. Year 2



Source: Danner and Phillips⁹⁶

⁹⁴ Boergers, J., C. Gable, and J. Owens. "Later School Start Time Associated with Improved Sleep and Daytime Functioning." Op. cit. p. 15.

⁹⁵ Danner, F. and B. Phillips. "Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes." Op. cit.

⁹⁶ Ibid.

A similar study was conducted in Virginia where researchers compared the teen crash rates of Virginia Beach and Chesapeake, two similar and neighboring cities with different high school start times. Virginia Beach high schools started 75-80 minutes earlier than the high schools in Chesapeake. The study compared the crash data for 16 to 18 year old drivers in 2007 and 2008 across the two cities, and found that Virginia Beach had higher teen car crash rates. While all drivers (excluding 16 to 18 year olds) in Virginia Beach generally had higher rates of car crashes than Chesapeake drivers, the difference was far more pronounced for teen drivers. In fact, Vorona et al. found that the difference in teen crashes between the two cities were 4.5 times higher than the crash rate difference for all other ages.⁹⁷

Finally, Wahlstrom et al.'s 2014 study included teen car crash data for 16 to 18 year old drivers in three areas in Minnesota, and in Teton County, Wyoming. These authors found that in three of four communities, car crash rates dropped when high schools instituted later start times. The rate of car accidents dropped by as much as 70 percent in one district. The fourth district saw a small increase of 9 percent in their crash rates, which the authors suspect is due to crashes involving "teens who attend local high schools in other nearby districts with earlier start times."⁹⁸

TIME ON HOMEWORK, ATHLETICS, AND EXTRACURRICULARS

A common critique of later start times and subsequently later release times is that it leaves less time for students to do their homework and participate in afterschool activities. Generally, the literature finds no negative impact on participation in extracurricular activities and athletics afterschool due to a delay in school start times. One study also finds that later start times are associated with more time spent on homework and less time watching TV.

Boergers et al., cited previously in this section, found that later school start times did not have an effect on the amount of time students spent working on their homework. There were also "no significant difference in hours spent on...school sports, organized community sports, music activities, volunteer work, or hanging out with friends."⁹⁹ These researchers also found no change in tiredness during sports or social activities.¹⁰⁰

Based on teacher focus groups and interviews in Wahlstrom's 2002 study, teachers reported that districts that started later in the morning had shortened practices, extended-day

⁹⁷ Vorona, R., M. Szklo-Coxe, A. Wu, M. Dubik, Y. Zhao, and J. Ware. "Dissimilar teen crash rates in two neighboring southeastern Virginia cities with different high school start times." Op. cit.

⁹⁸ Wahlstrom, K. "Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study." Op. cit., p. 48.

⁹⁹ Boergers et al., Op. cit. p. 15.

¹⁰⁰ Ibid.

programs, and rehearsals in the afternoons. These teachers did note that levels of participation in afterschool activities did not change due to school start times, however.¹⁰¹

APS's start time study found that students participated in after school activities at the same level or more after the change in start times for both middle and high schools. More specifically, 65 percent of high schoolers "indicated that either there was no difference in their participation or that they were participating more in 2001-02."¹⁰² Likewise, 24 percent of middle schoolers reported no difference in their participation and 42 percent were participating more. The authors suggest that the earlier start time in the middle school allowed for additional programming and/or after school activities coordinators.¹⁰³

Finally, the 2012 Edwards study (described in detail in Section I) also examined self-reported data from students about how much time they spent each day doing homework and watching television. He found that students who started school one hour later watched 12 minutes less of television each day and spent nine minutes more on homework each week. Edwards hypothesized that this was the case because students who started school earlier came home earlier and may spend more time alone watching television (and not being supervised on homework) before their parents arrive home.¹⁰⁴

¹⁰¹ "Wahlstrom, K. "Changing Times: Findings From the First Longitudinal Study of Later High School Start Times." Op. cit.

¹⁰² "Wahlstrom, K. "Changing Times: Findings From the First Longitudinal Study of Later High School Start Times." Op. cit., p. 23

¹⁰³ Ibid.

¹⁰⁴ Edwards, F. "Early to rise? The effect of daily start times on academic performance." Op. cit. p. 982.

SECTION III: SLEEP NEEDS AND SLEEP OUTCOMES OF ELEMENTARY SCHOOL-AGED STUDENTS

It is common knowledge among parents of elementary school-aged students that sleep is important to their children's health. However, the amount and quality of sleep required by children at each age and stage of development is not often clearly understood. In this section, Hanover Research examines literature on the science of sleep, and the sleep needs of elementary school-aged students.

THE SCIENCE OF SLEEP

To understand the majority of research surrounding the sleep patterns of young children, it is necessary to have a basic understanding of the science of sleep. The sleep cycle is comprised of two phases that range from light sleep to deep sleep. The two main phases are Rapid Eye Movement Sleep (REM) and Non-REM Sleep (NREM).¹⁰⁵

- **REM Sleep:** This phase of sleep involves extensive brain activity but during this phase of sleep the body suppresses muscle activity. This is the point of sleep in which dreaming occurs.¹⁰⁶
- **NREM Sleep:** This level of sleep has four stages within that range, from light sleep to the deepest sleep possible, that is also referred to as Slow-Wave Sleep (SWS).¹⁰⁷
 - Stage 1: A period of light sleep that bridges being awake and being asleep
 - Stage 2: The period where light sleep transitions into deeper sleep. This stage is marked by changes in brain-wave patterns.
 - Stage 3-4: The periods of deepest sleep that comprises about 12 to 15 percent of total sleep time.¹⁰⁸ The amount of time spent in SWS sleep varies depending on how long a person has been awake prior to sleeping. Children usually experience large amounts of Stage 3-4 sleep that progressively decreases as they get older.¹⁰⁹

Aging has an impact on the amount of sleep required and the way a person regulates their sleep. Infants require the most sleep and usually average about 16 hours a day while the adult averages approximately eight hours per night.¹¹⁰ Although sleep habits change slightly

¹⁰⁵ "Sleep." Encyclopedia of Children's Health. <http://www.healthofchildren.com/S/Sleep.html>

¹⁰⁶ Ibid.

¹⁰⁷ Ibid.

¹⁰⁸ Ibid.

¹⁰⁹ Dahl, R. and D. Lewin. "Pathways to Adolescent Health: Sleep Regulation and Behavior." *Journal of Adolescent Health*. 2002. p. 177. <http://www.sciencedirect.com/science/article/pii/S1054139X02005062#>

¹¹⁰ Ibid. p. 177.

as a person ages, there are four areas of sleep needs that are systematically altered during the transition from childhood into adolescence:

- There is a decrease in the duration of REM and Stage 3-4 sleep
- A more adult-like pattern of REM sleep develops
- There is an increase in daytime sleepiness
- There is a shift in the circadian pattern toward a preference for later bedtimes and wake-up times

Though all these changes are important, the shift in the circadian pattern is most notable in regards to school start times. The circadian timing system is the function of sleep that regulates the timing associated with waking and sleeping during a daily cycle.¹¹¹ For younger children, parents often play an integral role in the child's development of appropriate time cues for a sleep-wake cycle through enforced bedtimes. The majority of children under the age of 10 will sleep for approximately ten hours before they wake up naturally on a school day or a weekend.¹¹² During puberty notable biological circadian changes occur and adolescents shift toward a preference for delayed circadian patterns, meaning teens naturally prefer to stay up later and sleep in later.¹¹³ This occurrence is coupled with the fact that teens often set their own bed times and have access to a variety of stimulating night-time activities including videogames, television, and internet.¹¹⁴

CIRCADIAN RHYTHMS FOR YOUNG CHILDREN

The majority of research revolving around circadian rhythms focuses on very young children (infants and toddlers), children with sleeping disabilities, or concentrates on the shift that occurs at adolescence; therefore information about circadian rhythms in healthy elementary aged children is extremely limited.

One of Carskadon's first studies on the circadian timing in young children was a survey of 275 Sixth Grade girls on their physical development and circadian phase preference (i.e., their preference for mornings or evenings). The study found a significant relationship between the girls' physical development and their circadian patterns – the more mature girls favored later hours while the less mature girls favored earlier hours.¹¹⁵

¹¹¹ Carskadon, M. "Sleep and Circadian Rhythms in Children and Adolescents: Relevance for Athletic Performance of Young People." *Clinics in Sports Medicine*. 2005. p. 319. <http://www.ncbi.nlm.nih.gov/pubmed/15892926>

¹¹² *Ibid.*, p. 320.

¹¹³ "Pathways to Adolescent Health: Sleep Regulation and Behavior." *Op. cit.* p. 179

¹¹⁴ Carskadon, M., "Sleep and Circadian Rhythms in Children and Adolescents: Relevance for Athletic Performance of Young People." *Op. Cit.* p. 320.

¹¹⁵ Carskadon, M., C. Vieira, and C. Acebo. "Association Between Puberty and Delayed Phase Preference." *Sleep*, 16, 1993, pp. 258-62, as cited from Carskadon, M. "When Worlds Collide: Adolescent Need for Sleep Versus Societal Demands." Phi Delta Kappa International, Inc. 1999. p. 3. https://www.spps.org/uploads/when_worlds_collide-carskadon.pdf

According to Jenni and Carskadon, the shift in circadian sleep phase preference begins to occur in children sometime between ages 6 to 12, thus it is not possible to determine the ideal bedtime for all children at a specific age since the biological changes occur so variably. It is important to note that the elementary years comprise a formative period wherein problematic sleep habits tend to develop in children.¹¹⁶

SLEEP DURATION AND PATTERNS FOR YOUNG CHILDREN

According to research presented by the National Sleep Foundation, sleep needs vary among individuals, as some people require more sleep than others.¹¹⁷ However, sufficient sleep is essential to the healthy development of young children, especially between 5 and 12 years of age, when children experience rapid development. The sleep needs of elementary school-aged students change as children develop.¹¹⁸ While preschool-aged students (ages 3 to 5 years) require 11 to 13 hours of sleep each night, elementary school-aged children (ages 5 to 12 years) require 10 to 11 hours of sleep.¹¹⁹

In addition to sleep duration, children's sleep patterns change as they develop. While young children typically require daytime naps as well as a long nighttime session, sleep typically becomes consolidated into a single nighttime session when children reach ages 6 or 7.¹²⁰

While preschool-aged students require 11 to 13 hours of sleep each night, elementary school-aged children require 10 to 11 hours of sleep.

School-aged children's sleep is characterized by 50-minute cycles of deep, slow-wave sleep. During slow-wave sleep, brain activity declines and it becomes increasingly difficult to awaken.¹²¹ Research suggests that slow-wave sleep contributes to children's learning and memory.¹²² However, the number of slow-wave sleep periods decline as children enter the early stages of adulthood.¹²³

Other habits and activities may impact the amount and quality of sleep that elementary school students receive each night. Increasing academic demands from school, as well as sports and extracurricular commitments, may delay children's sleep time. In addition, the

¹¹⁶ Jenni, O. and M. Carskadon. "Normal Human Sleep at Different Ages: Infants to Adolescents." Sleep Research Society. p. 14. <http://www.scifun.org/conversations/Conversations4Teachers/Chapter%201.pdf>

¹¹⁷ "How Much Sleep Do We Really Need?" National Sleep Foundation. <http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need>

¹¹⁸ Amschler, D.H. and J.F. McKenzie. Elementary Students' Sleep Habits and Teacher Observations of Sleep-Related Problems." The Journal of School Health, 75:2, February 2005. p. 50.

¹¹⁹ "Children and Sleep." National Sleep Foundation. <http://sleepfoundation.org/sleep-topics/children-and-sleep/page/0%2C2/>

¹²⁰ "Changes in Sleep with Age." Division of Sleep Medicine at Harvard Medical School. <http://healthysleep.med.harvard.edu/healthy/science/variations/changes-in-sleep-with-age>

¹²¹ "Natural Patterns of Sleep." Division of Sleep Medicine at Harvard Medical School.

<http://healthysleep.med.harvard.edu/healthy/science/what/sleep-patterns-rem-nrem>

¹²² Buckhalt, J.A. "School Year Means Sleep Challenges for Kids of All Ages." American Psychological Association, August 27, 2012. <http://www.apa.org/news/press/releases/2012/08/sleep-challenges.aspx>

¹²³ "Changes in Sleep with Age." Op. cit.

use of television, computers, and other devices can disrupt sleep and cause students to go to bed later. According to the National Sleep Foundation, watching TV at night is associated with “bedtime resistance, difficulty falling asleep, anxiety around sleep, and sleeping fewer hours.”¹²⁴ To ensure children receive sufficient and quality rest, the National Sleep Foundation recommends the following practices:¹²⁵

- Teach school-aged children about healthy sleep habits.
- Continue to emphasize need for regular and consistent sleep schedule and bedtime routine.
- Make child's bedroom conducive to sleep – dark, cool and quiet.
- Keep TV and computers out of the bedroom.
- Avoid caffeine.

SLEEP OUTCOMES FOR YOUNG CHILDREN

Though much of the research surrounding sleep needs is focused on infants and adolescents, the problems associated with lack of sleep are not limited to these groups. Approximately 11 to 12 percent of elementary school children experience daytime sleepiness and 18 to 21 percent report daytime fatigue.¹²⁶ A number of researchers have also maintained that sleep plays an important role in brain development and learning during childhood:

The influence of problem sleepiness on children is multidimensional and may include decreased cognitive functioning and academic performance, increased aggression, and other behavioral problems, and increase vulnerability to accidents.¹²⁷

A 2004 study conducted by James Spilsbury examined the sleep habits of 755 school children between the ages of 8 to 11 living in urban areas of Cleveland, Ohio. The study required the children to complete a seven-day sleep journal and their guardian also had to complete a questionnaire about the child’s sleep and health. The study concluded that overall, a large portion of elementary school-aged children sleep less than the recommended nine hours per night. However, the *mean* sleep duration for all children was 9.63 hours and the analysis showed a statistically significant decrease in mean sleep duration as children got older. Minority boys reported the least amount of sleep time; in fact, the shortest mean sleep duration was reported among older minority boys (9.28 hours, see Figure 3.1). In addition, 43 percent of 10 to 11 year-old boys reported less than nine hours of sleep per night. The study also examined bedtimes and found that minority

¹²⁴“Children and Sleep.” National Sleep Foundation. <http://sleepfoundation.org/sleep-topics/children-and-sleep/page/0%2C3/>

¹²⁵Bulleted points taken verbatim from: “Children and Sleep.” Op. cit.

¹²⁶Spilsbury, et al. “Sleep Behavior in an Urban US Sample of School-aged Children.” *The Journal of the American Medical Association Pediatrics*. 2004. <http://archpedi.jamanetwork.com/article.aspx?articleid=485834>

¹²⁷Ibid.

children were more likely than nonminority children to have a bedtime of 11 p.m. or later.¹²⁸

Figure 3.1: Adjusted Mean Length of Sleep

ETHNICITY AND GENDER	8.5 YEARS OLD	9.5 YEARS OLD	10.5 YEARS OLD
Nonminority girls	9.85	9.69	9.55
Nonminority boys	9.82	9.67	9.52
Minority girls	9.83	9.68	9.53
Minority boys	9.58	9.43	9.28

Source: Spilsbury¹²⁹

COGNITIVE DEVELOPMENT

In order to be successful in school settings, children must be able to listen to a teacher’s instructions, apply what they are taught, and retain new concepts; therefore cognitive abilities are particularly important to student achievement. There has been vast research about the cognitive effects of reduced sleep on adults, but the research on elementary-aged children is somewhat limited due to the ethical concerns associated with depriving young children of sleep.¹³⁰ The studies that do exist find that children’s cognitive performance is at least somewhat impacted by their amount of sleep.

Randazzo and her peers conducted a study in 1998 to test the cognitive functioning of children following acute sleep restriction. The research included 16 children between the ages of 10 and 14 years old and took place over the course of one day. The children were randomly assigned to a control group or a sleep restriction group (treatment group), for one night while in a sleep laboratory. Those children in the control group were given 11 hours in bed while the children in the sleep restriction group were given only five hours in bed. The following day, both groups were evaluated on their cognitive performance and sleepiness measures during four sessions throughout the day that occurred every two hours. The authors concluded that executive function skills, such as skills that “enable the individual to engage in creative, adaptive learning by initiating and regulating retrieval of knowledge from long-term memory, modifying the knowledge base, and mediating problem-solving” may be impaired by sleep loss.¹³¹ Notably, measures of rote performance and less-complex forms of cognitive functioning, like memorization, were similar across both groups. The authors suggest that the nature of routine/rote tasks (i.e., low cognitive load) account for the lack of differences between the two groups.¹³²

¹²⁸ Ibid.

¹²⁹ Ibid., p. 991

¹³⁰ Buckhalt, J. “Sleep Loss Affects Children’s Ability to Process Speech.” *Psychology Today*. 2013. <http://www.psychologytoday.com/blog/child-sleep-zzzs/201303/sleep-loss-affects-children-s-ability-process-speech>

¹³¹ Randazzo, AC, et al. “Cognitive function following acute sleep restriction in children ages 10-14.” *National Center for Biotechnology Information*. 1998. p. 866. <http://www.ncbi.nlm.nih.gov/pubmed/9871948>

¹³² Ibid.

A comparable study led by Dennis Molfese also studied the effects of sleep on six children from ages 6 to 8. The researchers asked the parents of these children to record the sleeping patterns of their children for one week.¹³³ After the normal sleeping patterns were recorded, the researchers assigned some students to the experimental group and assigned the rest to a control group. The children in the experimental group were allowed to sleep for one hour less every night for a week while the control group remained on their normal sleeping schedule. After a week of mild sleep restriction for the experimental group, the children were given a series of tasks designed to measure their attention, speech perception, and executive function. Those students in the experimental group showed slower responses. Overall, the Molfese study demonstrated that even small amounts of sleep deprivation can have a negative impact on children's cognitive functioning.¹³⁴

HEALTH

The health of young children is also associated with the amount of sleep they receive. Some studies find an increase in depression and violence in the home, while others find a relationship between obesity and sleep.

A 2007 study conducted by researchers at the Columbia School of Nursing sought to examine the characteristics associated with inadequate sleep in children. The study examined a nationally representative sample of 68,418 children between the ages of 6 and 17 years old. The researchers then divided the children into two subpopulations based on their age range, from age 6 to 11, and 12 to 17. The data utilized in this study came from parent interview responses about children's sleep habits and other characteristics. The related health characteristics of school-aged children (6 to 11 years) with or without adequate sleep as reported by parents are included in Figure 3.2. Inadequate sleep indicated that the child did not sleep well at least one night the week prior to the survey.¹³⁵

The authors found the following factors to be associated with children with inadequate sleep in both age groups:¹³⁶

- Presence of one or more depressive symptoms,
- Less frequent days of physical activity,
- Living in a home where parents argue heatedly or shout,
- On rare occasions respond by hitting or throwing things during family disagreements, or

¹³³ Molfese, D., et al. "A One-Hour Sleep Restriction Impacts Brain Processing in Young Children Across Tasks: Evidence From Event-Related Potentials." *Developmental Neuropsychology*. 2013. <http://www.tandfonline.com/doi/full/10.1080/87565641.2013.799169#tabModule>

¹³⁴ Buckhalt, J. "Sleep Loss Affects Children's Ability to Process Speech." *Op cit*.

¹³⁵ Smaldone, A. et al. "Sleepless in America: Inadequate Sleep and Relationships to Health and Well-being of Our Nation's Children." *American Academy of Pediatrics*. 2006. http://pediatrics.aappublications.org/content/119/Supplement_1/S29.full.pdf+html

¹³⁶ Quoted with minor changes from: *Ibid.*, p. S31

- Perceive that the environment at home, school, or in the community is not always safe.

Specifically for elementary-aged children, inadequate sleep was associated with having problems at school, and fair or poor paternal general health.¹³⁷

Figure 3.2: Characteristics of Children With or Without Adequate Sleep

VARIABLE	INADEQUATE SLEEP	ADEQUATE SLEEP
Health Status		
Excellent	57.3	62.1
Very good, good	38.4	34.9
Fair, poor	4.3	3.0
Comorbid conditions		
Depression/anxiety	5.3	2.9
Behavioral conduct problem	8.7	5.3
Developmental delay or physical impairment	3.7	3.8
Atopic conduction	32.4	29.1
Frequent or severe headache	5.9	4.4
Learning disability	11.2	9.3
ADD/ADHD	9.6	7.1
Depressive symptoms		
Never	11.4	19.7
Sometimes	73.0	69.8
Always, usually	15.6	10.5
Physical Health		
Overweight	27.5	28.3

Source: Smaldone et al.¹³⁸

A 2007 study examined the potential link between shorter sleep duration and childhood weight problems. The study analyzed the sleep duration and BMI data of 785 children in the third and sixth grade. The sleep duration was reported by parents and the height and weight of children were measured. The study defined “overweight” as a BMI greater than or equal to the 95th percentile for age and gender; 18 percent of the children included in this study were overweight in the sixth grade. Through logistic regression modeling, the study found that shorter sleep duration in Grade 6 was independently associated with a greater likelihood of being overweight. In addition, shorter sleep duration in Grade 3 was also independently associated with being overweight in the Sixth Grade after controlling for a child’s Third Grade weight status.¹³⁹

¹³⁷ Ibid.

¹³⁸ Ibid. p. S32

¹³⁹ Lumeng, J., et al. “Shorter Sleep Duration is Associated with Increased Risk for Being Overweight at Ages 9 to 12 Years.” *Pediatrics*. 2007. <http://pediatrics.aappublications.org/content/120/5/1020>

An additional study published in 2014 also links childhood obesity to reduced sleep during infancy and early childhood. The mothers involved in this study were recruited during early pregnancy, and followed their children from age 6 months to 7 years. These mothers were asked about their child's sleep duration as they aged, along with a variety of body measurements that were taken when the children were 7 years old.¹⁴⁰ Children were assigned a sleep score ranging from 0 to 13 based on the amount of sleep reported by their mother. A score of 0 specified the highest level of sleep deprivation whereas a score of 13 indicated no reports of deficient sleep. A lack of sleep for this study was defined as:¹⁴¹

- 6 months- 2 years old: less the 12 hours per day
- 3-4 years old: less than ten hours per day
- 5-7 years old: less than nine hours per day

The researchers of this study found that the children in households with lower incomes and lower maternal education were likely to have lower sleep scores. Minority children were also more likely to receive less sleep. When examining the relationship of sleep with body fat, Taveras et al. found that "chronic sleep curtailment throughout infancy to mid-childhood was associated with higher overall and central adiposity [body fat] at age 7 years."¹⁴²

¹⁴⁰ Taveras, E., M. Gillman, M. Pena, S. Redline, and S. Rifas-Shiman. "Chronic Sleep Curtailment and Adiposity."

Pediatrics. 2014. <http://pediatrics.aappublications.org/content/early/2014/05/14/peds.2013-3065.full.pdf+html>

¹⁴¹ "Chronic Insufficient Sleep Increases Obesity, Overall Body Fat in Children." Massachusetts General Hospital. http://www.eurekalert.org/pub_releases/2014-05/mgh-cis051414.php

¹⁴² Taveras et al., Op. cit., p. 1017

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