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Effects of Four-Day School Weeks on Adolescents: Examining Impacts of the Schedule on Academic Achievement, Attendance, and Behavior in High School

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Effects of Four-Day School Weeks on Adolescents:

Examining Impacts of the Schedule on Academic Achievement, Attendance, and Behavior in High School

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Abstract

Four-day school weeks have proliferated across the United States in recent years, reaching over 650 public school districts in 24 states as of 2019, but little is known about the effects of the four-day school week on high school students. This study uses district-level panel data from Oklahoma and a difference-in-differences research design to provide the first estimates of the causal effect of the four-day school week on high school students' ACT scores, attendance, and disciplinary incidents during school. Results indicate that four-day school weeks decrease per-pupil bullying incidents by approximately 31% and per-pupil fighting incidents by approximately 27%, but have no detectable effect on other incident types, ACT scores, or attendance.

A small body of literature on the effects of four-day school weeks has developed over the past six years, but the scope of this work has been limited. Most of the existing research has focused on economic issues, such as school finance (Thompson, 2021a; Morton, 2021), parental labor supply (Ward, 2019), and housing prices (Nowak, Perrone, & Smith, 2019), or academic outcomes among younger students in grades 3-8 (Anderson & Walker, 2015; Morton, 2021; Thompson, 2021b). To date, the only study that considers outcomes of the four-day school week for high-school aged students examines the effect of the four-day school week on juvenile crime (Fischer & Argyle, 2018). Thus, with the exception of Fischer and Argyle's (2018) study on juvenile crime, there is a dearth of evidence concerning the implications of four-day weeks for high school-age students, who are primary stakeholders for the four-day school week policy, as they comprise nearly a third of all K-12 students. This study seeks to address this gap in our understanding of the effects of four-day school weeks on all students, with a particular focus on effects that have important implications for policy and have potential to vary based on students' age or developmental status.

As is discussed further in this paper, sociological theory and evidence from cognitive developmental science suggest that the changes to a student's schedule elicited by a four-day school week could have different effects on academic and behavioral outcomes for high school-age adolescents and young children. In this paper, I employ quasi-experimental research methods and district-level high school data from Oklahoma to provide the first estimates of the effect of the four-day school week on high school adolescents' academic achievement, attendance, and school behaviors. More specifically, I examine yearly ACT scores, attendance, and behavioral incidents at school as outcomes.

Background on Four-Day School Weeks

Implementation

State policies that enable four-day school weeks typically require districts to meet a minimum number of instructional hours without mandating a minimum number of instructional days. To implement a four-day week, districts typically increase the length of the weekdays they are in school and have Fridays or Mondays off. A survey of a representative sample of four-day week districts finds that, on the off day or the "fifth day," nearly half are completely closed or offer no student services and less than one third offer any sort of activity to students with any frequency (Thompson et al., 2020). How students actually spend their time on the fifth day is unknown.

Growth

Originating as early as the 1930s in South Dakota, the schedule is not an entirely new phenomenon, but it has seen unprecedented growth in its adoption over the past two decades, increasing from 257 schools across 108 districts in 1999 to 1,607 schools across 662 school districts in 24 states[1] in 2019 (Thompson et al., 2020). Indeed, this estimate is conservative, and many more schools may operate on four-day weeks than is currently thought to be true. COVID-19 has brought additional attention to the policy, as a broader range of districts have recently turned to four-day weeks in response to the economic and logistical challenges of COVID-19 (Altavena, 2020; Haas, 2020). Four-day week districts have historically been located in rural areas and have relatively fewer students than other districts in the state, but there are a few districts that are exceptions to this pattern; for example, an urban district in Colorado that serves 18,000 students adopted a four-day week at the start of the 2018-2019 school year and two urban

[1] States with at least one school operating on a four-day school week schedule during the 2018-2019 school year were: Alaska, Arizona, California, Colorado, Georgia, Idaho, Iowa, Kansas, Louisiana, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Texas, Washington, and Wyoming.

districts in Arizona that each serve over 12,000 students will adopt a four-day week for the 2020-2021 school year in response to COVID-19 (Altavena, 2020).

Rationale

A 2020 study of 342 four-day districts nationwide finds the most common rationale (selected by 65.1% of districts) for adopting a four-day school week was financial savings in the areas of transportation, school operations, and support staff salaries and benefits (Thompson et al., 2020). Other reasons for adoption (selected by 25-35% of districts) included attendance-related issues (e.g., low attendance rates, missing school for appointments or athletics) and issues related to being in a rural area (e.g., long bus rides, time to work on family farms and ranches, student/teacher retention). Prior research suggests that districts who adopt the schedule reduce their expenditures by only 1-2% on average as a result of the schedule change, but attendance is not significantly affected among students in grades 3-8 (Anderson & Walker, 2015; Thompson, 2021b). Whether the other rationales and intended consequences of four-day school weeks have been realized by the districts who have adopted them remain empirically unfounded.

Oklahoma Policy Context

Popular press articles indicate that the four-day school week has been very controversial in Oklahoma (e.g., Ferguson, 2020). Despite extensive support for the schedule among school administrators, teachers, parents, and students who have four-day weeks, the State Superintendent Joy Hofmeister argues against them, claiming that “forcing the academic year into fewer and longer days with extended weekly gaps in instruction does not create an optimal learning environment for our students” (Hofmeister, 2019). The controversy has spurred recent changes in Oklahoma state policy regarding school calendars.

Policy Changes

Four-day school weeks first became possible in Oklahoma with the passing of House Bill 1864 in the wake of the Great Recession in April 2009 (H.B. 1864 [2009]). The policy changed the requirements for districts such that they no longer needed to operate for 180 days and 1,080 hours of classroom instruction per year; rather, they only needed to meet the 1,080 hours requirement. As a result, districts could operate for fewer than 180 days per year if they met the required 1,080 hours.

In response to the disapproval of four-day school weeks from State Superintendent Joy Hofmeister and Republican concern that four-day school weeks harm the state's reputation and students' education, the policy was recently changed by Senate Bill 441 in May 2019 (Forman, 2019; S.B. 441 [2019]). The bill requires districts to operate for 165 instructional days as well as 1,080 hours per year beginning in the 2022-2023[2] school year. The average four-day school week district operates for 148 days per year (Thompson et al., 2020), and the 165-day requirement would essentially force them to switch back to five-day weeks (Martinez-Keel, 2020). However, the bill includes a clause that allows schools to operate for fewer than 165 days if they can meet minimum guidelines for student performance and school district cost savings, in which case they must submit an application to the State Department of Education by June 30 each year to receive a 1-year waiver that must also be renewed every year.

The guidelines were proposed by the Oklahoma State Department of Education and State Superintendent Joy Hofmeister, and they were signed into law by the Governor through an executive order in February 2020. The guidelines require elementary and middles schools to (1) have received a letter grade of "C" or higher on their student growth indicator on their most recent Oklahoma School Report Card and (2) not be currently identified for Comprehensive

[2] Senate Bill 441 originally required districts to uphold the 165 days and 1,080 hours requirements for the 2021-2022 school year, but all districts were granted a waiver for 2021-2022 due to COVID-19.

Support and Improvement (CSI), Target Support and Improvement (TSI), or Additional Targeted Support and Improvement (ATSI). High schools must (1) have a 4-year cohort graduation rate equal to or greater than the most recent state average, (2) have received a letter grade of "C" or higher on their academic achievement indicator on their most recent Oklahoma School Report Card, (3) have received a letter grade of "C" or higher on their postsecondary opportunities indicator on their most recent Oklahoma School Report Card, and (4) not be currently identified for Comprehensive Support and Improvement (CSI), Target Support and Improvement (TSI), or Additional Targeted Support and Improvement (ATSI). Additionally, any district applying for a waiver must submit a budget and narrative describing their cost savings to the County Excise Board.

There is additional controversy over the consequences of these minimum requirements. Four-day school week advocates claim that many five-day week districts considered to be high performing districts would not qualify under these requirements, and only seven percent of the districts that had four-day school weeks in the 2019-2020 school year would qualify for a waiver (Ferguson, 2020). Hofmeister alternatively claims that 51% of all Oklahoma schools and 46% of all four-day school week schools meet the requirements for a waiver (Martinez-Keel, 2020). For many four-day week districts, advocates caution, these minimum guidelines could mean completely closing the district because they will not be able to manage the financial burden of adding back a fifth school day (Martinez-Keel, 2020). Despite evidence that cost savings from adopting the four-day school are limited (~2%; Morton, 2021; Thompson, 2021a), it is possible that switching back to a five-day week could cost a district more than it ever saved (e.g., students leave the district for private school or another state with four-day weeks). Most of this debate has occurred with little rigorous evidence of the effects of the four-day week on students in

Oklahoma, as the first study of Oklahoma students was published only in August of 2020 (Morton, 2021).

Policy Implementation

Sixteen Oklahoma districts first recorded the complete schedule change, meaning every full school week on their calendar was planned to be four days long, in the fall of 2010, immediately following the policy change. The number of districts operating on the schedule increased steadily in the following years until the 2016-2017 school year and stayed relatively stable from then through the spring of 2019 (see Appendix Figure A1 for the timing of four-day school week adoption in Oklahoma). At the start of the 2018-2019 school year, 92 of Oklahoma's 513 (17.9%) public school districts had at least one school on a four-day week schedule. The likely expansion of four-day school weeks in 2019-2020 and 2020-2021 due to COVID-19 has not yet been publicized.

Effects of the Four-Day School Week on Students

Until recently, research on the four-day school week was limited to anecdotal evidence from interviews and opinion surveys that generally touted various benefits of the schedule for students. In the last six years, several studies have employed panel data to make causal inferences about effects of attending a four-day week school as opposed to a five-day week school for students. These studies provide important preliminary evidence regarding the effects of the schedule, but additional research is needed to build a comprehensive understanding of its consequences. For example, most of the quasi-experimental research considering effects on students to date has focused on estimating effects on achievement and attendance, despite the anecdotal claims that the schedule has broad effects on students' morale and engagement in school, behavior and disciplinary infractions, opportunities for extracurricular development, and

health. Furthermore, the existing research has almost exclusively focused on students in grades 3-8, despite the fact that districts across the county almost always implement the four-day school week across all grades, K-12. This study helps to narrow these gaps by providing the first estimates of effects of the four-day school week on high school students' achievement, attendance, and school behaviors.

Academic Achievement

The existing research on the effects of the four-day school week on academic achievement have not reached a consensus. Using school-level data from fourth- and fifth-grade students in Colorado and a difference-in-differences strategy, Anderson and Walker (2015) find that the percentage of students scoring above the proficiency threshold in math and English Language Arts (ELA) on the state test increased by 4-7 percentage points as an effect of the four-day school week. Morton (2021) leverages the same identification strategy with district-level data from Oklahoma students in grades 3-8 and estimates negative average effects (-0.03 SD to -0.05 SD) on standardized math and ELA achievement, but the effects are not statistically significant. Using the same difference-in-differences approach with student-level data, Thompson (2020) finds similar but statistically significant average effects (-0.03 SD to -0.06 SD) of switching to a four-day school week on standardized math and reading test scores of students in grades 3-8 in Oregon. He further demonstrates that the decrease can be attributed, at least in part, to four-day schools' average 3.5 fewer hours of time students spend at school per week compared to the five-day schools in his sample. He also finds no significant heterogeneous effects based on student characteristics with the exception of special education status, which predicts faring better on a four-day week, and English Language Learner (ELL) status, which predicts faring worse. The older students in his sample, the 7th and 8th grade students, are also

more negatively affected by the four-day school week in terms of their academic achievement relative to the younger students in the sample. The 8th grade students experience the largest negative impact of the schedule, with their test scores decreasing by 0.09 SD in math and 0.06 SD in reading.

Although these different average results across states could reflect real differences in the average effect of the policy by state, they more likely reflect the large amount of variation in the implementation of the policy and its effects on academics by district, resulting in statistical noisiness in the estimations (Thompson et al., 2020). One can imagine that factors with a well-established relationship to student achievement, such as student attendance, instructional time, teacher quality and retention, and student fatigue, could vary greatly based on a district's specific implementation of the policy and drive differences in the effects of the schedule by district.

Attendance

Despite an abundance of anecdotal evidence that four-day school weeks improve attendance, the two quasi-experimental studies existing to date find no effect. The anecdotal evidence, primarily based on interviews and opinion surveys, argues that attendance increases on a four-day week because students are able to use the fifth day for activities and appointments for which they might otherwise miss school (Hale, 2007; Hanson, 2017; Hedtke, 2014; Kingsbury, 2008; Leiseth, 2008; Schank, 2009; Smith, 2009; Toppo, 2002; Turner, 2010). These situations are likely to be particularly relevant in the remote, rural areas that have four-day school weeks due to the lengthy travel that can be required to get to doctors' offices and athletics games at other schools. Indeed, Thompson et al.'s (2020) national study of four-day school week adoption and implementation provides support for the idea that districts believe attendance improves on the schedule. He found ~29% of districts cited "attendance issues related to things such as long

commutes for school-sponsored athletic events or family appointments" as a primary motivation for their initial adoption of the four-day week (Thompson et al., 2020).

The empirical, quasi-experimental research on the effect of four-day weeks, however, does not provide support for these claims. Embedded within their aforementioned achievement studies, Anderson and Walker (2015) and Thompson (2020) examine attendance among students in grades 3-8 as a mechanism that could be driving effects on achievement. Using the same difference-in-differences analysis strategy, both studies estimate a small (~0-1%) and statistically insignificant effect of the four-day week on attendance rates.

The discrepancies in the anecdotal and empirical evidence could be explained in several ways. For example, (1) the perceived improvements in attendance could merely be perceptions that are borne out in reality, (2) the populations for whom attendance is improving could not represented in the empirical samples, or (3) attendance could be improving in such a way that it is not captured by the traditional measurement of attendance, average daily attendance (ADA). The present study will address the second possibility by considering the effect of the four-day school week on attendance among high school students. I discuss the first and third possibilities and their implications for the present study further in the Discussion section.

Behavior

Student behavior is not commonly indicated as a reason districts adopt a four-day school week (Thompson et al., 2020), but many anecdotal accounts report that the four-day week improves students' morale and behavior (Dam, 2006; Donis-Keller & Silvernail, 2009; Hale, 2007; Hanson, 2017; Hedtke, 2014; Koki, 1992; Leiseth, 2008; Shoemaker, 2002). These accounts argue that the four-day school week increases students' affinity for going to school and reduces disciplinary incidents at school. A cross-sectional study comparing students on four-day

and five-day week schedules across 234 Colorado high schools in 2017 provides some descriptive support for these anecdotal claims (Israel et al., 2020). More specifically, the researchers use multiple logistic regression, controlling for school-level demographic characteristics, to compare self-report survey responses from the two groups of students. They find that four-day week students are significantly less likely to report skipping school, using marijuana, cigarettes, or prescription drugs, or driving when under the influence of drugs or alcohol. However, they also find that four-day week students are more likely to report being bullied. The researchers emphasize the need for longitudinal research to further investigate potential causal effects of the four-day week underlying their mixed findings.

The existing quasi-experimental research on the effects of the four-day school week on student behavior considers a limited set of outcomes. Fischer and Argyle (2018) use a difference-in-differences strategy to estimate the effect of the four-day school week on juvenile crime. Using county-level panel data from Colorado, they find that the four-day school week increases juvenile crime by nearly 20%, and these increases are concentrated in property crime during times that students are not in school. This finding is alarming and suggests that four-day school weeks can have important, negative implications for adolescents' more severe behaviors outside of school that can be classified as public offenses. Nevertheless, it does not speak to the four-day school week's influence on the more common and less severe negative student behaviors disciplined at the school-level (e.g., alcohol or drug possession, vandalism, bullying, fighting, school bus incidents, etc.), which districts report are decreasing in the anecdotal studies.

Thompson's (2021b) Oregon achievement study provides some limited insight into the effect of the schedule on students' behaviors at school, but he considers only the fraction of days students miss for disciplinary infractions as an outcome. He finds no detectable effect of four-

day school weeks on the fraction of days students miss for disciplinary infractions (i.e., out-of-school suspensions) among students in grades 3-8 in Oregon. This finding provides some evidence that opposes the anecdotal reports that disciplinary incidents decrease in schools, but, again, the generalizability of the finding to more common negative student behaviors that do not result in out-of-school suspensions is limited. Furthermore, Thompson's (2020) study includes students only in grades 3-8, whereas the effect of the schedule on discipline could be concentrated among high school students.

Once again, the discrepancies between the estimated causal effects and the anecdotal reports warrants investigation. This study will provide the first estimates of the causal effect of the four-day school week on various student behaviors that warrant disciplinary action among high school students. Understanding the four-day school week's effect on such behavioral incidents in school is important because inflicting or being a victim of such infractions can dramatically affect students' short- and long-term trajectories as well as the school climate for all students (Kupchik, 2016; Nickerson et al., 2014; Schoeler et al., 2018; Skiba, Arredondo, & Williams, 2014). Moreover, estimating the effect of the schedule on various types of negative behaviors will enable policymakers and practitioners to understand the range of consequences of a four-day school week for students and enable targeted policy reform if necessary.

Four-Day School Weeks and Adolescence

There are strong empirical and theoretical reasons to expect academic and behavioral consequences of four-day school weeks for high school students to be different from those of the population that researchers have focused on to date, students in grades 3-8. High school students typically range in age from 14 to 19 years old and are developmentally considered to be "older adolescents" (Sawyer et al., 2018). Broadly, adolescence marks a time of significant

physiological and cognitive development that corresponds with the onset of puberty, which typically begins when students are in middle school, or 6th-8th grade (Sawyer et al., 2018). Research on the effects of four-day school weeks on students to date have focused on the average effects on students in grades 3-8 (Morton, 2021; Thompson, 2021b) or grades 4 and 5 (Anderson & Walker, 2015); because these studies focused on *average* effects, they primarily describe the effects of the schedule on elementary students. Only Thompson (2020) additionally considers grade-based heterogeneity of the effect of four-day weeks on achievement in his grades 3-8 sample. Indeed, he provides the first evidence that early adolescents may be differentially affected by four-day school weeks than elementary school-aged children: he finds that the achievement of 7th and 8th grade students was more negatively affected by the four-day school week than that of the younger students in his sample, with the most negative effects concentrated in 8th grade (i.e., 13 to 14 years old). However, Thompson (2020) does not conduct this analysis of grade-level effect heterogeneity for his attendance or behavior outcomes.

Thus, the research on the effects of four-day weeks to date generally estimates average effects of the policy on students in elementary and middle school with limited ability to parse the effects of the policy on adolescents from elementary students, and it has no ability to identify the effects of the policy on older adolescents. Though there is individual variation in developmental timing such that some early high school students may not yet be experiencing many of the developmental changes associated with older adolescence, this study operationalizes older adolescence as the ages during which students are in high school, as most high school-aged students would be considered older adolescents (Sawyer et al., 2018). Nevertheless, because the existing literature has failed to consider how any aspects of younger or older adolescence would

be related to effects of the four-day school week, this study details the potential, theoretical influence of aspects of general adolescence as well as specific aspects of older adolescence.

More specifically, some of the developmental changes that occur during adolescence are likely to make various features of a four-day school week more or less harmful for students' achievement and behavior in high school. Though many features and consequences of four-day school weeks may similarly affect students of all ages, developmental theory and other empirical findings regarding adolescence point to several features of four-day school weeks whose effects are likely to vary for high school students relative to elementary students based on students' developmental status: (1) earlier start times, (2) longer school days and classes, and (3) increased free and/or unsupervised time.

Earlier Start Times

Both younger and older adolescents are particularly likely to be affected by earlier start times because of changes to circadian rhythms that occur at puberty (Dahl & Lewin, 2002). These circadian changes influence the release timing of the hormone melatonin such that adolescents are naturally predisposed to having later bedtimes and have a difficult time adjusting to earlier bedtimes. Therefore, earlier school start times are associated with students getting less sleep on school nights, as adolescents may struggle to adjust to an earlier bedtime despite having an earlier wake time (Edwards, 2012). Earlier start times and diminished sleep have been shown to have negative effects on adolescents' academic performance, attention, disciplinary infractions, and attendance (American Academy of Pediatrics, 2014; Lufi et al., 2011; Owens et al., 2010; Thacher & Onyper, 2016; Wahistrom, 2002; Heissel & Norris, 2018). It is important to note, though, that most of the empirical research considering the effect of start times estimates the effect of changing a start time by at least 30 minutes, whereas the national difference in start

times between four-day and five-day school week schools is only 11 minutes. Thus, the earlier start times at four-day week schools may be harmful to adolescents' achievement, attendance, and school behavior, but the extent of their likely impact is unknown.

Longer School Days and Classes

However, older adolescents may have a particular advantage over younger adolescents and elementary students in their ability to adjust to the longer school days and class periods associated with four-day school weeks. The brain's prefrontal cortex undergoes significant development throughout adolescence, and is, therefore, most developed in older adolescence. The prefrontal cortex, located in the frontal lobe of the brain, is the area of the brain responsible for the most complex cognitive functions, such as planning, sustained attention, working memory, and goal-directed behavior (Paus, 2005; Thillay et al., 2015; Yurgelun-Todd, 2007). In the case of the four-day school week, these increased developmental capacities could improve a student's ability to succeed academically on the schedule by enabling them to focus over the course of a longer school day and to retain more information over the extended weekend than younger students. If the day is less cognitively taxing for high school students, there may be a range of related positive consequences, such as reduced stress, improved morale, increased attendance, and fewer disciplinary incidents.

Increased Free and/or Unsupervised Time

The increased free and/or unsupervised time that four-day week students likely have on their fifth day (and the night before) is also likely to have different effects on older adolescents. It is well-established that increased unsupervised out-of-school time is associated with various negative outcomes for older adolescents (Posner & Vandell, 1999), including reduced academic achievement (Mahoney, Cairns, & Farmer, 2003), increased antisocial behavior, and greater

frequency of risky behavior such as delinquency and substance use (Gage et al., 2005; Jacob & Lefgren, 2003; Mahoney, 2000). Indeed, as mentioned previously, Fischer and Argyle (2018) found that four-day school weeks led to almost a 20% increase in juvenile crime among high school students, concentrated during times the students were not at school. The increased negative behaviors can be explained in part by the cognitive development that takes place during older adolescence. Adolescents' limbic brain region, responsible for reward and highly sensitive to social and emotional stimuli, undergoes accelerated development that surpasses the development of the prefrontal cortex. This shift in the balance between the mesolimbic and mesocortical dopamine systems causes older adolescents to be more easily aroused by social and emotional stimuli, have less effective behavioral inhibition, and be more impulsive until their prefrontal cortex is fully developed in adulthood (Spear, 2000; Steinberg, 2007). Perhaps unsurprisingly, juvenile justice involvement and generally engaging in antisocial and risky behaviors outside of school has been shown to be positively associated with exhibiting such behaviors in school as well (Andershed, Kerr, & Stattin, 2001; Fabelo et al., 2011). Therefore, the increase in free and/or unsupervised time on a four-day school week may particularly put high school students at risk for increases in negative behaviors and disciplinary infractions at schools.

Overall, it is unlikely that the four-day school week only advantages or disadvantages high school students relative to younger students, but there is good reason to suspect that four-day school weeks could have different consequences for these older adolescents than their elementary and/or middle school counterparts. Given that the policy is currently being debated in many state legislatures, determining the currently unknown effects of the schedule on high

school students' achievement, attendance, and behavior could have important implications for policy and practice.

Research Questions

Despite tremendous national growth in four-day school weeks and controversial legislative debates regarding the policy, research on its effects is remarkably scarce. Indeed, the effect of the schedule on high school achievement is entirely unknown. Other frequently purported benefits of the policy, increased attendance and improved school behavior, have puzzlingly little empirical support to date but have not been examined among high school students. This study notably contributes the first estimates of the causal effect of the four-day school week on high school students' achievement, attendance, and disciplinary incidents. Estimating these effects using data from Oklahoma has the unique potential to inform future Oklahoma policy on school calendars. The study specifically seeks to answer the three following questions: What is the effect of the four-day school week on high school students' (1) math and English ACT scores, (2) attendance rates, and (3) per-pupil disciplinary incidents?

Methods

Data

This study employs 12 years (2007-08 to 2018-19) of demographic and ACT data, 9 years of attendance data (2010-11 to 2018-19), and 9 years of data (2009-10 to 2017-18) from annual behavioral incident reports from all 417 traditional public school districts in Oklahoma serving high school students. Because the four-day school week has never been adopted in a district in a "city" location as designated by the National Center for Education Statistics (NCES), the analytic sample excludes city districts (n=6). The complete panels include district-year observations from these 411 school districts in Oklahoma and were constructed using school-

level calendar data (available through 2018-19) from the Oklahoma State Department of Education (OSDE), district-level demographic data from the NCES Common Core of Data (CCD), district-level ACT data from OSDE, district-grade level attendance data from OSDE, and district-level behavioral incident reports from OSDE.

The district-level calendar data are constructed from high school school-level calendar data. None of the four-day week districts in the sample have multiple high schools serving the same district; thus, the treatment is effectively adopted at the district level. The CCD demographic data include each district's yearly number of students enrolled in grades 9-12, racial composition (available from only 2008-09 to 2018-19), percent of students eligible for free or reduced-price lunch (FRPL), percent of English language learners (ELLs), percent of special education students, and pupil-teacher ratio. The ACT data from OSDE include yearly estimates of each district's average math and English score for all students who took the test. Each section of the ACT is scored on a scale of 1-36. Attendance data include yearly district-grade-level average daily membership (ADM), the average number of students enrolled per day over the course of a school year, and average daily attendance (ADA), the average number of students recorded as present at school per day over the course of a school year. Oklahoma measures ADA such that students who are in attendance for two out of three periods before or after lunch are counted as attending for one half day. Students who miss class for school activities (e.g., sports, FFA competitions) are not marked as absent for those periods.[3] The behavioral incident reports data include annual district-level counts of the following incidents among students in grades 9-12: (1) possession, use, or sale of alcohol, illicit drugs, or tobacco, (2) vandalism, (3) bullying,

[3] Students can have up to 10 total absences (or 20 half-day absences) for school activities per year. Beyond these 10 allotted absences, students would have to be recorded as officially absent if they were to miss additional school for school activities.

(4) fighting or assault, (5) possession of or incidents with weapons (e.g., BB guns, knives) other than firearms, (6) school bus incidents, and (7) truancy.

Sample

The analytic sample is restricted to the Oklahoma districts that served high school students in a non-city location. City districts that serve high school students (n=6) are excluded because no four-day school weeks have ever been adopted in city-located districts in Oklahoma, and there are large qualitative differences between city districts and the primarily rural districts in which four-day school weeks are common. Thus, city districts are not likely to be a useful counterfactual for districts that adopt four-day school weeks.

Descriptive statistics presented in Table 1 indicate many significant differences ($p<.05$) between districts that always have five-day weeks (column 1), and those that ever adopt four-day school weeks (columns 2 and 3), as well as between districts that adopt four-day school weeks pre-adoption (column 2) and post-adoption (column 3). Some particularly notable average differences between districts that always have five-day weeks and districts that ever adopt four-day school weeks include four-day week districts' higher percentages of FRPL-eligible students, higher percentages of Native American students, smaller district memberships, lower ACT scores, and higher incident rates of truancy and alcohol, drugs, or tobacco. Additionally, as expected, districts that ever adopt four-day school weeks are located almost exclusively (94%) in rural areas, whereas the five-day week districts in the sample are located more evenly across rural (72%), town (22%), and suburban (5%) areas.

When comparing four-day week districts pre- and post-adoption, the differences are generally smaller in magnitude, but many are still statistically significant. More specifically, relative to their pre-adoption period when they are operating on five-day weeks, the four-day

week districts have higher percentages of FRPL-eligible students, smaller district memberships, lower ACT scores, and lower incident rates of bullying. Attendance rates and rates of all other incident types were similar across the two groups.

These descriptive differences are useful for considering average differences in the composition of the control and treatment samples, but it would be invalid to interpret these differences as *effects* of the four-day school week. These groups vary on other factors, such as the years during which they are observed, that could be driving the observed differences, as opposed to whether districts adopted a four-day school week. To address this issue, I use a quasi-experimental research design to estimate causal effects of the four-day school week.

Empirical Strategy

This study employs panel data and a quasi-experimental difference-in-differences approach to estimate causal effects of four-day school weeks by comparing the contemporaneous changes in outcomes of districts with four-day school weeks to those of districts that never or had not yet adopted four-day weeks. I estimate variations of the following difference-in-differences (DID) specification:

$$Y_{dt} = \lambda_d + \theta_t + \beta Fourday_{dt} + X'_{dt}\gamma + \epsilon_{dt} \quad (1)$$

where Y_{dt} is the dependent variable of interest (i.e., ACT math and English scores,[4] attendance rates (ADA/ADM*100) for each grade, or incident counts per pupil for each incident type), λ_d are district fixed effects, θ_t are year fixed effects, β represents the effect of the four-day week, $Fourday_{dt}$ is an indicator variable that takes on a value of one each year a district has a four-day week schedule, and ϵ_{dt} is an error term that accommodates for clustering at the district level

[4] Models were also run using standardized ACT math and English scores. The results of the static and semi-dynamic DID specifications were not statistically or substantively different from the results of the specification that used the scale scores.

(Bertrand, Duflo, & Mullainathan, 2004). X_{dt} is a vector of covariates that controls for potential shocks that vary within districts over time and are historically linked to academic outcomes, ADA, and behavioral incident counts. These covariates include, for each district-year observation, the percent FRPL-eligible students, the percent of students designated as ELLs, and the percent of special education students.

The interpretation of the estimates produced in Equation 1 relies on several important assumptions. One assumption is that the effect of four-day school weeks (i.e., the "treatment") is the same over time, or "static." However, the effect of a four-day week schedule could potentially vary depending on the length of time that students have been exposed to the schedule. For example, districts' ACT scores could decline significantly in the first year they switch to a four-day week as teachers adjust their curriculums, but then stabilize to their pre-switch levels in following years. Alternatively, the schedule could increasingly improve or harm districts' ACT scores each year of exposure to the schedule, resulting in a growing effect (positive or negative) of the four-day week over time. These considerations are also important in relation to attendance and discipline outcomes, as these outcomes could decrease or increase over time as districts adjust to and, ideally, learn how to optimize the schedule to promote attendance and reduce negative behaviors. To account for such potential time-varying treatment effects, I specify semi-dynamic fixed-effects DID models that allow the schedule to have distinct effects the first year, the second year, and after three or more years of having a four-day week:

$$Y_{dt} = \lambda_d + \theta_t + \sum_{\tau=0}^{2+} \beta_{+\tau} Fourday_{d,t+\tau} + X'_{dt}\gamma + \epsilon_{dt} \quad (2)$$

where τ is the number of years after a school has adopted the four-day schedule (the first year of adoption, $\tau = 0$) and $\beta_{+\tau}$ represents the effect of four-day weeks τ years after a district adopts

the schedule. Joint F-tests are additionally employed to test the null hypothesis of a constant treatment effect, H_0: $\beta_0 = \beta_1 = \beta_{2+}$.

The "parallel trends" assumption is another critical assumption for DID analyses. This assumption requires that changes in outcomes over time in "control" districts (i.e., districts that never or had not yet adopted the four-day schedule) are comparable to the changes that would have occurred in districts after they adopted four-day weeks if they had remained on five-day weeks. A violation of the parallel trends assumption would preclude the interpretation of the Equation 1 estimates as causal effects because the control group would not be a valid counterfactual for the treatment group over time. Because it is impossible to observe districts who do adopt four-day school weeks as five-day school weeks in the post-treatment period, the best way to test this assumption is to test for parallel trends in the pre-treatment period. Parallel trends would be assumed to be violated, for example, if districts that eventually adopted four-day weeks had decreasing ACT scores before they switched to the four-day week relative to districts that never switched. In that case, it would not be possible to attribute any changes in ACT scores post-treatment to the schedule change as opposed to the different trends existing between the treatment and control districts before treatment; in other words, such a finding would suggest that the untreated districts are unlikely to be a valid counterfactual for the treated districts in the post-treatment period. To empirically examine the parallel trends assumption, I use the Granger causality test ("event study") as a falsification check (Angrist & Pischke, 2009) that estimates the effect of the four-day week on the outcome variables for the years before and after the change:

$$Y_{dt} = \lambda_d + \theta_t + \sum_{\tau=2}^{4+} \beta_{-\tau} Fourday_{d,t-\tau} + \sum_{\tau=0}^{2+} \beta_{+\tau} Fourday_{d,t+\tau} + X'_{dt}\gamma + \epsilon_{dt} \qquad (3)$$

where $\beta_{-\tau}$ represents the "effect" of being τ years prior to adoption relative to never adopting four-day weeks or being one year pre-adoption. To uphold the parallel trends assumption, the estimated "effect" of eventual four-day week adoption should be constant and equal to zero in the years preceding adoption. Joint F-tests are employed to test the null hypothesis of a constant pre-treatment "effect" equal to zero, $H_0: \beta_{-4+} = \beta_{-3} = \beta_{-2} = 0$.

Another critical assumption embedded in the DID specification is related to selection bias. At the district-level, selection concerns are warranted because four-day weeks are not randomly assigned to districts and, rather, districts voluntarily choose whether to adopt four-day weeks. The inclusion of district fixed effects in all specifications helps to address this concern, as the fixed effects control for unobservable heterogeneity between districts averaged over time, such as the percent students in a district who qualify for FRPL. Rather, the chief threat with regard to selection is that treatment and control districts could be trending differently on district characteristics pre-adoption, and these differences could lead to adopting the four-day school week. For example, evidence that district membership decreases significantly more over time during the pre-treatment period in treatment districts than control districts would raise the concern that districts chose to adopt four-day weeks because they were losing students at a faster rate than other districts. In that case, it would be impossible to attribute any observed effect of the four-day school week in the post-treatment period to the schedule change as opposed to the decreasing membership in treatment districts during the pre-treatment period.

Selection concerns would also be warranted if students and families were systematically choosing to enter or exit four-day week districts (pre- or post-adoption) over time. This systematic entry and/or exit would have the potential to change the total enrollment in the district as well as the composition of the students in the district. Indeed, if students were systematically

exiting a district after it adopted a four-day week because they disliked the four-day week (and not being replaced by new students), enrollment would decrease in the year(s) following adoption, and the composition of the students would necessarily change such that a greater percentage of students and/or families would be in-favor of the four-day week. In such a situation, any observed effects of the four-day week could alternatively be attributed to the changes in the population of students at the district. However, substantial entry and/or exit into these districts is unlikely due to the rural location of most four-day week districts. Given that it is impossible to directly examine effects of the four-day week on student-level entry and exit without student-level data, I estimate the effects of the schedule on reasonable proxies: district-level enrollment and characteristics representative of the composition of the district (e.g., the percent of FRPL-eligible students).

Therefore, I employ the following specifications to examine assumptions about selection into and out of treatment:

$$X_{dt} = \lambda_d + \theta_t + \beta Fourday_{dt} + \epsilon_{dt} \quad (4)$$

$$X_{dt} = \lambda_d + \theta_t + \sum_{\tau=2}^{4+} \beta_{-\tau} Fourday_{d,t-\tau} + \sum_{\tau=0}^{2+} \beta_{+\tau} Fourday_{d,t+\tau} + \epsilon_{dt} \quad (5)$$

where X_{dt} represents time-variant district enrollments and characteristics (i.e., the natural log of grades 9-12 enrollment, the natural log of grades 9-12 ADM, the percent of white students, the percent of Native American students, the percent of FRPL-eligible students, the percent of students in special education, and the pupil-teacher ratio). The event study in Equation 5 provides a further interrogation of the DID estimates from Equation 4.

The specifications that examine ACT scores as outcomes require additional robustness checks related to selection and missingness. Current Oklahoma policy requires all grade 11

students to take either the ACT or SAT, but, prior to the 2017-2018 school year, the ACT was offered to high school students on an opt-in basis. Thus, the percentage of students taking the ACT varies across districts and years. There are also some years in which districts have no students who take the ACT. Lacking outcome data, these districts are excluded from the analytic sample for each "missing" district-year observation. Evidence of a pre-treatment or post-treatment "effect" of four-day school weeks on (1) the percentage of students taking the ACT or (2) district-level missingness from the ACT sample would be problematic for the interpretation of DID specifications examining ACT outcomes because it would suggest that the four-day school week affected who was represented in the ACT sample. It could be, for example, that adopting a four-day school week makes students or an entire district less likely to participate in the ACT because there is less time at school to prepare for, take, or administer the test at school over the course of the school year. In that case, it would be impossible to attribute any observed effect on ACT scores to the four-day school week as opposed to concurrent changes at four-day week districts in (1) the population of students who take the ACT or (2) district-level participation in the ACT. To test for these "effects," I specify equations that replicate the static DID and event study specifications respectively presented in Equations 1 and 3 but use ACT participation rates and missingness as the outcomes:

$$H_{dt} = \lambda_d + \theta_t + \beta Fourday_{dt} + X'_{dt}\gamma + \epsilon_{dt} \quad (6)$$

$$H_{dt} = \lambda_d + \theta_t + \sum_{\tau=2}^{4+} \beta_{-\tau} Fourday_{d,t-\tau} + \sum_{\tau=0}^{2+} \beta_{+\tau} Fourday_{d,t+\tau} + X'_{dt}\gamma + \epsilon_{dt} \quad (7)$$

where H_{dt} represents (1) the percent of students who took the ACT and (2) ACT district-level missingness (yes/no).

As an additional robustness check regarding the sensitivity of the baseline estimates to the specified control group, I conduct the Equation 1 DID analyses with two additional, more restrictive control groups. Descriptive statistics for these control groups are presented in Appendix Table A5. The first alternative control group limits the control group to five-day week districts in rural locations (n=262). This control group is a valuable comparison group because treated districts are almost exclusively rural (94%) and four-day school weeks are known to be a rural phenomenon; therefore, rural five-day week districts may provide a better counterfactual for four-day week districts than all non-city five-day week districts. The second alternative control group is created using one-to-one (i.e., k:1) nearest neighbor propensity score matching without replacement or caliper restrictions (Rubin, 1973). This method generates propensity scores predicting all districts' likelihood of receiving treatment and identifies, for each treated district (n=90), the untreated district (n=90) that is most similar based on a vector of observable district characteristics (see all district characteristics listed in Table 1). Propensity scores for the districts that adopt a four-day school week within the study period (M=0.333, SD=0.128) were reasonably similar to and not statistically significantly different from those of the matched comparison group (M=0.326, SD=0.137).

A final robustness check is required to address an assumption embedded in DID specifications with variation in treatment timing, such as the specification used in this study. When there is variation in treatment timing and the effects of treatment vary over time, the fixed effects DID estimator represents a weighted average of all two-group by two-period DID estimators (Goodman-Bacon, 2018). In the DID specification in Equation 1, the two groups being compared are the treated districts, districts that operate on a four-day week in a particular year, and the control districts, districts operating on a five-day week in the same year (whether or

not they later adopt a four-day week). The weights on each 2x2 comparison are determined by the proportion of districts in the treatment versus control group and the variance of treatment status. Whereas the proportion of treated districts will be highest in comparisons made toward the end of the study period, the variance of treatment status will be largest in comparisons made toward the beginning of the study period. Therefore, districts that adopt the four-day week in the middle of the study period will have the highest overall weights and could be overrepresented in the fixed effects DID estimator. This overrepresentation would be problematic if treatment effects were to vary over time. Gibbons, Serrato, and Urbancic (2018) further argue that these weighted average fixed effects estimators can poorly represent the average treatment effect (ATE), and they are especially likely to poorly represent the ATE if there are heterogeneous treatment effects by treatment time. To address this issue, they developed an estimator of the ATE that reweights the observations to produce consistent and unbiased point estimates. I implement this regression-weighted estimator (RWE) and find that, although there are qualitative differences in some of the estimates due to the noisiness of particular estimates, the Gibbons et al. (2018) Wald tests indicate that the none of the differences between the RWE estimates (i.e., the ATE) and the OLS fixed-effects estimates are statistically significant.

Results

Difference-in-Differences

DID and semi-dynamic DID analyses, as specified in Equations 1 and 2, were conducted examining the effect of the four-day school week on the following outcomes: math and English ACT scores, the natural log of 9^{th}-12^{th} grade ADA, and the natural log of counts of seven types of disciplinary infractions in grades 9-12.

ACT Scores

The DID and semi-dynamic DID point estimates of the effect of four-day weeks on districts' math and English test scores are presented in Table 2. Though the majority of the point estimates are positive, all point estimates in both the static DID and semi-dynamic DID models are statistically insignificant from zero and meaningfully small (i.e., less than or equal to 0.35 points on the ACT), indicating there is no detectable effect of the four-day week on ACT scores. The joint F-tests conducted for each semi-dynamic DID specification also fail to reject a constant treatment effect over time on math and English ACT scores.

Attendance

The DID and semi-dynamic DID point estimates of the effect of four-day weeks on the high school attendance rates (attendance rate = ADA/ADM * 100) in total and in each grade are presented in Table 3. These point estimates can be interpreted as average percentage point change in districts' attendance rates due to the four-day school week. Though the majority of the point estimates are negative, the static estimates of the effect for each grade as well as all high school grades are statistically insignificant and small, approximately 0.04 to 0.24 percentage point decreases, indicating there is no detectable effect of the four-day school week on attendance rates. The corresponding joint F-tests also fail to reject constant treatment effects over time on the total high school attendance rates and attendance rates in each high school grade.

School Disciplinary Incidents

The DID and semi-dynamic DID point estimates of the effect of four-day weeks on the rate of school disciplinary incidents per pupil by incident type are presented in Table 4. These point estimates can be interpreted as the average change in districts' frequency of incidents per pupil for each incident type due to the four-day school week. The results suggest that four-day weeks significantly decreased the frequency of bullying incidents per pupil by 0.52 incidents per

student, which is approximately 31% fewer incidents than four-day districts had before they adopted the four-day week. Four-day weeks also significantly decreased fighting and assault incidents per pupil by 0.68 incidents per student, which is approximately 27% fewer incidents than four-day districts had before adopting the four-day week. The four-day week did not have a significant static effect on the per-pupil rates of all remaining incident types, including alcohol/drugs/tobacco, vandalism, weapons, school bus, and truancy incidents. The joint F-tests for all semi-dynamic DID specifications with per-pupil disciplinary incidents as outcomes also fail to reject constant treatment effects over time. Nevertheless, it is worth noting that the semi-dynamic DID specifications identify a significant decrease in per-pupil school bus incidents (β=-0.24, SE=0.12, p<.05) in the first year of adoption.

Robustness Checks

Results of the event study specifications, as detailed in Equation 3, that were employed to test the robustness of the parallel trends assumptions embedded in the static and semi-dynamic DID specifications presented in Tables 2, 3, and 4 are respectively presented in Appendix Tables A1, A2, and A3. The event studies provide suggestive evidence regarding whether, conditional on district and year fixed effects, outcomes of districts that would adopt a four-day school week but had not yet adopted it ("2 year lead," "3 year lead," etc.) were trending differently relative to the outcomes of districts in the year preceding adoption of the four-day week and districts that would not adopt a four-day week. The results presented in Appendix Tables A1, A2, and A3, respectively depicted in Figures A2, A3, and A4 fail to reject the null hypothesis that there are no significant differences between the treatment and control districts before treatment for any of the examined outcomes. The joint F-tests examining "effects" of four-day weeks on all outcomes during the pre-adoption period also fail to reject the null hypothesis that the effects of being a

district in the years preceding adoption of the four-day week were constant and equal to zero, providing further support for the parallel trends assumption.

A second set of robustness checks test for selection into and out of treatment by examining the association between district characteristics (e.g., enrollment, racial composition) and adopting a four-day school week over time. I test for such potential selection bias related to four-day week adoption by regressing time-variant district characteristics on the four-day week conditional on time and district fixed effects, as specified in Equations 4 and 5. The examined time-variant district characteristics include (a) district enrollment in grades 9-12 (Table 5): yearly enrollment in grades 9-12 and total ADM for grades 9-12, and (b) other district characteristics (Appendix Table A5): the percent of white students, the percent of Native American students, the percent of students who are FRPL-eligible, the percent of special education students, and the student-teacher ratio. All of the point estimates in Table 5 and Appendix Table A5 are substantively small and statistically insignificant, indicating that I fail to reject the null hypotheses that (1) districts are not selecting into treatment due to changes in district characteristics during the pre-treatment period and (2) districts are not changing with respect to those same characteristics during the post-treatment period. Therefore, I find no strong evidence for selection into or out of treatment based on observables using this method.

The analyses estimating effects of the four-day week on ACT scores require additional robustness checks related to selection. As previously described, analyses using ACT scores are potentially subject to selection bias based on the variation in the percentage of students who choose to take the ACT between and within districts over time as well as the missingness of ACT scores for several districts. Using the specifications in Equations 6 and 7, I test for "effects" of the four-day week on the percentage of students taking the ACT in a district and on whether or

not a district reported any ACT scores. As displayed in Appendix Table A4, all of the point estimates are statistically insignificant, indicating that I fail to reject the null hypothesis that there are no selection effects related to (1) the percentage of students taking the ACT in a district or (2) district-level participation in the ACT.

Lastly, I additionally test the sensitivity of the baseline results by repeating the analyses with two alternative, more restrictive control groups. More specifically, I conduct the same static DID and semi-dynamic DID specifications (Equations 1 and 2) with the previously defined alternative control groups: (1) a matched comparison group of control districts and (2) rural-only control districts. Descriptive statistics for the two alternative control groups are presented alongside descriptive statistics of the treatment group pre- and post-adoption in Appendix Table A6. The static DID and semi-dynamic DID analyses conducted using each alternative control group are presented for the ACT score outcomes in Appendix Table A7, for the attendance outcomes in Appendix Table A8, and for the disciplinary incident outcomes in Appendix Table A9. The reported point estimates in these tables are similar in both magnitude and statistical significance to those of the original analyses presented in Tables 2, 3, and 4. Thus, these results provide additional evidence that the baseline results are robust to the use of alternative control groups.

Discussion

State-level policy decisions on four-day school weeks across the country are being made without any evidence regarding the schedule's effects on high school students. This study used panel data from Oklahoma public high school districts and a difference-in-differences research design to provide the first rigorous, quasi-experimental analysis of the effects of the four-day school week on high school students' achievement, attendance, and behavior.

I find no detectable effect of the schedule on districts' average ACT scores in math or English. Because no other study has considered the effects of the schedule on high school students' achievement, I am confined to interpreting the null effect in the context of the existing state-based studies of achievement in grades 3-8. The null effect reported in this study aligns with Morton's (2021) null finding on students' state test scores in grades 3-8 in Oklahoma. There was a theoretical basis to expect that four-day school weeks would affect high school students differently from younger students, but it is possible that the various mechanisms through which the four-day week positively and negatively affects high school students' achievement relative to younger students' achievement essentially cancel out such that all students were similarly affected by the schedule. Perhaps the mechanisms driving the effects that are specific to high school-age students are precisely opposite in magnitude: high school students could have fared worse because of the earlier start times but fared equally better because of their advanced cognitive capacities to pay attention through the longer classes and days.

This study's null result regarding achievement also contradicts that of Anderson and Walker (2015), who find positive effects of the schedule on student achievement in grades 4 and 5 in Colorado, and that of Thompson (2020), who finds negative effects of the schedule on student achievement in grades 3-8, with the most negative effects concentrated in grades 7 and 8. The lack of a detectable effect in the current study is surprising in contrast to the concentration of the negative academic effects among the older, middle school-age students in Thompson's (2020) study; however, it is difficult to compare these results simultaneously across developmental age groups and states, as there could also be significant state-based differences in the implementation and consequences of the policy (and state-based differences could also vary by developmental age group). Therefore, many questions remain regarding the mechanisms

underlying observed academic effects of four-day school weeks, but the null results on ACT scores presented in this study provide the most rigorous and relevant estimate of the effect of four-day school weeks on high school students to date for the policymakers and practitioners debating four-day school weeks in Oklahoma.

With regard to attendance, I also find no detectable effect of the four-day school week on attendance rates in any high school grade. This finding aligns with Anderson and Walker's (2015) and Thompson's (2020) estimated null effects on attendance among students in grades 3-8, but it makes the strong and frequent anecdotal claims that attendance is improving difficult to explain. Indeed, 29% of four-day week districts from a national sample of four-day week districts cited attendance issues as one of their primary reasons for adopting the four-day school week. Anecdotal evidence based on surveys and interviews of four-day week district members indicates that they think attendance increases on a four-day school week because students can use the fifth day for activities and appointments (e.g., sports games/tournaments, FFA competitions, doctor's appointments) that they would otherwise have to miss regular school hours to attend (Hale, 2007; Hanson, 2017; Hedtke, 2014; Kingsbury, 2008; Leiseth, 2008; Schank, 2009; Smith, 2009; Toppo, 2002; Turner, 2010). It is possible, of course, that four-day school week district members simply misperceive the schedule as improving student attendance when there is no effect. In that case, I would recommend discouraging the adoption of four-day school weeks with the sole purpose of improving attendance.

However, if attendance increases at four-day week districts precisely because students are missing less class time for school activities like sports, it is possible that the attendance measure used in this study and in the other quasi-experimental studies would not capture these changes. More specifically, the ADA measure used in Oklahoma, as well as that of Colorado and Oregon,

does not record class time that students miss for school activities as an absence. It is conceivable that students who are old enough to participate in school activities at these districts would frequently have to miss class when on a five-day week schedule to make the long trip to compete at other districts because of their rural location. Missing school for an appointment, however, would be recorded as an official absence (even if excused) that would appear in the ADA measure. Therefore, if students were previously missing significant amounts of class time for school activities, it is possible that these districts were increasing their attendance rates in terms of the percentage of time students were in class, but these increases would not appear in analyses that uses the most common measure of attendance, ADA. Because of this potential for systematic measurement error to be biasing the results, future research should investigate the role of school activity-related absences in reported increases in attendance at four-day school week districts.

Lastly, this study finds that four-day school weeks significantly decrease high school students' disciplinary incidents related to bullying and fighting at school, but they have no detectable effect on incidents related to alcohol/drugs/tobacco, vandalism, weapons, school bus rides, and truancy. Bullying incidents reduced by 0.52 (95% CI: -0.97, -0.08) incidents per pupil, a 31% decrease, and fighting incidents reduced by 0.68 (95% CI: -1.16, -0.19) incidents per pupil, a 27% decrease. At first, the decreases in and null effects on disciplinary incidents are surprising given high school students' increased free time and likely reduced supervision on the four-day school week. However, these specific changes are concentrated during time spent outside of school, and it is possible that any changes in behavior outside of school are not translating to the behaviors in school measured in this study. The decreases in and null effects on in-school disciplinary incidents per pupil could also be attributed to students' spending less time at school and having less time to commit these infractions when they switch to a four-day school

week. According to Thompson et al.'s (2020) study of the implementation of four-day school weeks, students at four-day week districts spend 7% less time at school and have 18% fewer school days on average than five-day week students over the course of a year.

It would be reasonable to expect that changes in the frequency of incidents that can occur at any point in the day, such as bullying and fighting, would be more related to changes to the total time students are at school than changes to the number of school days. However, this claim relies on the assumption that these incidents are equally distributed throughout the day and not concentrated during discrete periods of the day, such as lunch and recess. Unfortunately, to the best of my knowledge, no peer-reviewed research has documented the distribution of these various incidents throughout the day, week, and/or year, so this assumption is untested. If these incidents occurred only during lunch (and the length of lunch periods were not impacted by the four-day week schedule), for example, one would expect their frequency to be more closely connected to the number of days students are at school. Therefore, if the four-day school week had no effect on student behavior other than reducing the time or days students are at school, one might expect incidents that can occur throughout the day (e.g., bullying and fighting) to reduce by ~7%, or up to ~18% at most. However, this study finds that bullying and fighting incidents per pupil respectively decrease by 31% (95% CI: -58%, -5%) and 27% (95% CI: -46%, -8%), suggesting that the four-day school week is likely having a positive effect on these student behaviors over and above simply reducing the time (or days) students spend at school. These average decreases are greater than the estimated average 20-23% decreases in bullying attributed to school-based anti-bullying programs based on Ttofi and Farrington's (2011) meta-analysis of 44 programs.

Alternatively, for incidents that can only occur once per day (e.g., truancy) or during discrete periods of the day whose duration is unchanged by the four-day school week (e.g., school bus rides), it would be reasonable to assume that their frequency would be connected to the total days of school as opposed to total time at school. Thus, if four-day weeks had no effect on the frequency of these incidents outside of reducing total days of school, the frequency of these incidents per pupil should decrease by ~18%. This study estimates that per-pupil school bus incidents reduce by 25% (95% CI: -56%, +6%) and per-pupil truancy reduces by 9% (95% CI: -37%, +19%) on average, but neither effect is statistically significant from zero or an 18% decrease, so I cannot reject the possibility that the four-day school week has no effect on these incidents or is reducing them proportionately to the reduction in days of school. For the remaining examined types of incidents: alcohol/drugs/tobacco, vandalism, and weapons, it is less immediately clear whether their frequency would be better predicted by time at school or days of school. Nevertheless, all estimated effects of the four-day school week on the rate of these incidents per pupil were also not statistically significant from zero or a decrease of up to 18%, so I cannot reject the possibility that the four-day school week has no effect on these incidents or is reducing them proportionately to the reduction in time at school or days of school.

A comprehensive understanding of the four-day school week's impact on student behavior will require future research that examines effects on students' behavior both inside and outside of school. Nevertheless, the four-day school week's effective reduction of in-school bullying and fighting incidents per pupil, both in absolute terms and relative to the decreases in time at school, have important implications for policy and practice. School-based disciplinary incidents, such as bullying and fighting, can have substantial long-term negative consequences for both the victims and perpetrators of the incidents (Kupchik, 2016; Nickerson et al., 2014;

Schoeler et al., 2018; Skiba, Arredondo, & Williams, 2014); minimizing these incidents is often a priority for schools (Ttofi & Farrington, 2011), and the four-day school week may be an effective way to do so in rural districts like those in the present study. Nevertheless, it is worthwhile to recognize that these positive effects on high school students' behavior are most likely an unexpected positive consequence of the policy rather than the intent of the policy; indeed, districts do not report adopting the schedule for the purpose of reducing disciplinary incidents (Thompson et al., 2020). The unexpected nature of the effect raises questions about the underlying mechanism(s) driving the effect and other potential unintended consequences: perhaps four-day school weeks reduce bullying and fighting incidents by improving students' morale, reducing students' stress, increasing students' weekly sleep, or generally improving school climate. These questions warrant additional research, as the range of effects of the four-day school week is only minimally understood despite the policy's continued growth across the country and controversial political nature.

The generalizability of the results presented in this study to other districts located outside of Oklahoma depends on the consistency of the implementation of the four-day school week schedule, the differences between the districts and students experiencing the schedule, and the differences in students' opportunities and experiences on the "fifth day" across states. Whether true state-based differences exist in the nuanced implementation and resulting consequences of the four-day school week largely remains to be seen. Thompson et al.'s (2020) implementation and adoption study provides the first high-level evidence of state-based variation in schools' rationales for adopting the schedule and the opportunities they offer students on the fifth day, but the study does not link any differences in implementation to effects of the schedule. The existing body of research on four-day school weeks also has yet to adequately examine individual

differences in the effects of the schedule and potential disparities that arise from any such differences. Further describing the implementation of the schedule, related effects, and individual differences in its effects in future research will have important implications for policymakers considering placing restrictions on the implementation of the schedule and for practitioners considering adopting, abandoning, or adjusting the implementation of the schedule in their own district.

In Oklahoma, most districts will no longer be able to operate on a four-day school week as of the 2022-2023 school year because they will not meet the requirements for achievement and cost savings established by the State Department of Education. This February 2020 decision was made without any peer-reviewed empirical evidence regarding the policy in Oklahoma, as the first study of the state's four-day week, which found null effects of the schedule on achievement in grades 3-8, was published online in August of 2020 (Morton, 2021). Many four-day week superintendents are hoping that they will have the evidence they need to persuade the legislature to let them continue to operate on four-day school weeks beyond the 2021-2022 school year. It is my hope that the null findings on high school students' achievement and attendance as well as the promising effects on bullying and fighting presented in this study will help to inform these ongoing policy debates and any resulting revisions of requirements for schools to be eligible to operate on a four-day school week in Oklahoma.

Table 1: Descriptive Statistics

	Analytic sample					
	All non-city five-day districts (n=321)		Four-day districts pre-adoption (n=90)[a]		Four-day districts post-adoption (n=90)[a]	
District-level variables	Mean	SD	Mean	SD	Mean	SD
District characteristics						
% FRPL-eligible	54.87	17.67	61.16	14.42	65.09	14.30
% ELL	3.38	5.91	1.35	4.19	1.63	2.00
% Special ed.	17.01	4.64	18.68	4.18	20.05	4.36
% White	61.42	16.66	58.41	17.54	56.40	16.75
% Native American	21.70	17.18	32.16	18.84	28.61	19.04
% Asian	0.83	1.48	0.50	0.61	0.50	0.76
% Hispanic	8.67	10.43	3.64	3.06	5.46	4.69
% Black	3.19	6.97	2.45	4.38	2.03	4.13
% Other	4.09	6.51	2.81	4.43	6.99	8.82
District HS enrollment	379.70	694.35	164.72	151.23	156.10	151.42
Pupil-teacher ratio	13.66	5.64	12.87	3.49	13.02	2.94
Location						
% Rural	72.31	44.75	94.17	20.78	94.57	22.55
% Town	22.36	41.67	4.10	17.38	3.21	17.41
% Suburb	5.34	22.48	1.73	12.00	2.22	14.82
% City	0.00	0.00	0.00	0.00	0.00	0.00
ACT participation and scores						
Participation (n)	69.17	138.23	30.45	37.02	33.05	29.65
English	18.45	1.78	18.14	1.70	16.77	1.06
Math	19.07	2.26	18.92	1.83	16.75	1.49
Attendance rates[b] (%)						
Grade 9	94.84	1.88	94.68	1.65	94.94	1.45
Grade 10	94.59	1.95	94.43	1.66	94.65	1.71
Grade 11	94.60	2.14	94.64	1.68	94.75	1.96
Grade 12	94.46	2.53	94.73	1.80	94.77	2.17
Incidents per student[c]						
Alcohol, drugs, or tobacco	2.21	2.52	2.83	2.29	2.09	2.40
Vandalism	0.22	0.77	0.37	0.60	0.25	0.50
Bullying	1.11	2.23	1.67	2.04	0.65	0.84
Fighting or assault	1.86	2.38	2.53	2.04	1.78	2.19
Weapons	0.26	0.59	0.26	0.33	0.17	0.34
School bus	0.31	0.88	0.48	0.68	0.26	0.58
Truancy	2.76	5.33	2.64	3.42	1.75	2.51

[a] Observations are weighted such that each pre- and post-adoption district is equally represented in their respective category, regardless of the year they adopted the four-day school week.
[b] Attendance rates are calculated by dividing districts' reported grades 9-12 Average Daily Attendance by grades 9-12 Average Daily Membership, and the data include district observations for 9 years, from spring 2011-2019.
[c] Incident data include district observations for 10 years, from spring 2010-2019.
Notes: The panel data in this table include the 411 non-city districts serving high school students in Oklahoma observed annually for 12 years (except as otherwise noted) from SY 2007-2008 to SY 2018-2019 (N=4,932). HS = high school. FRPL = Free or Reduced-Price Lunch. ELL = English language learners.

Table 2: Effects of the Four-Day School Week on ACT Scores

	Dependent variables: ACT scores			
	Math ACT		English ACT	
Independent variable	(1)	(2)	(3)	(4)
Four-day	0.14		0.04	
	(0.17)		(0.18)	
Adoption year		-0.05		-0.18
		(0.14)		(0.16)
1 year lag		0.35		0.35
		(0.21)		(0.22)
2+ year lag		0.32		0.22
		(0.25)		(0.27)
Adj. R^2	0.5456	0.5464	0.6019	0.6024
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.2717	-	0.1509

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2008 to 2019, but 134 districts did not test students on the ACT or have missing data for at least one year. In total, ACT scores are not observed for 342 out of 4,932 district-year cells (N=4,590). Not testing students or having missing ACT data in a given year was not related to adopting a four-day school week (see Table 8). Schedule data and ACT data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).
*p<.05, **p<.01, ***p<.001

Table 3: Effects of the Four-Day School Week on Attendance Rates

	Dependent variables: Attendance rates[a]									
	9th grade		10th grade		11th grade		12th grade		Total 9th-12th grade	
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Four-day	-0.044		-0.131		-0.237		-0.141		-0.158	
	(0.160)		(0.202)		(0.212)		(0.229)		(0.165)	
Adoption year		0.027		-0.054		-0.315		-0.094		-0.147
		(0.209)		(0.228)		(0.245)		(0.263)		(0.188)
1 year lag		0.204		0.065		0.023		-0.321		-0.011
		(0.198)		(0.230)		(0.269)		(0.335)		(0.208)
2+ year lag		-0.354		-0.040		-0.507		-0.395		-0.345
		(0.253)		(0.283)		(0.275)		(0.320)		(0.224)
Adj. R^2	0.5379	0.5388	0.5079	0.5075	0.5086	0.5090	0.5452	0.5453	0.6617	0.6618
p-value: (H_0: $\beta_0 = \beta_1 = \beta_{2+}$)	-	0.0549	-	0.8437	-	0.1408	-	0.5307	-	0.2333

[a]Attendance rates are calculated using the following equation: Attendance rate = (Average Daily Attendance / Average Daily Membership) * 100. Point estimates can be interpreted as the percentage point change in attendance rate.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2011 to 2019 (N=3,699). Schedule data and attendance data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).

*p<.05, **p<.01, ***p<.001

Table 4: Effects of the Four-Day School Week on School Disciplinary Incidents Per Pupil

	Dependent variables: Incidents per pupil[a]													
	Alcohol, drugs, or tobacco		Vandalism		Bullying		Fighting or assault		Weapons		School bus		Truancy	
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Four-day	-0.44		-0.04		-0.52*		-0.68**		-0.01		-0.12		-0.26	
	(0.31)		(0.09)		(0.22)		(0.25)		(0.06)		(0.08)		(0.40)	
Adoption year		-0.38		-0.01		-0.64*		-0.49		-0.07		-0.24*		-0.14
		(0.37)		(0.09)		(0.28)		(0.43)		(0.06)		(0.12)		(0.45)
1 year lag		-0.52		-0.01		-0.31		-0.76*		-0.02		-0.07		-0.31
		(0.37)		(0.14)		(0.28)		(0.36)		(0.08)		(0.10)		(0.48)
2+ year lag		0.18		-0.19		-0.68*		-0.61		-0.03		-0.15		-0.60
		(0.51)		(0.11)		(0.32)		(0.45)		(0.09)		(0.13)		(0.62)
Adj. R^2	0.2849	0.2851	0.0603	0.0606	0.2019	0.2016	0.2495	0.2486	0.1167	0.1163	0.1141	0.1143	0.3380	0.3377
p-value: (H_0: $\beta_0 = \beta_1 = \beta_{2+}$)	-	0.1465	-	0.2230	-	0.4248	-	0.8258	-	0.7704	-	0.4167	-	0.7150

[a]Incidents per pupil are calculated using the following equation: Incidents per pupil = Incident count / Grades 9-12 enrollment.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2010 to 2018 (N=3,699). Schedule data and attendance data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).

*p<.05, **p<.01, ***p<.001

Table 5: Effects of the Four-Day School Week on District Enrollment (Event Study)

	Dependent variables: District enrollment			
	ln(grades 9-12 enrollment[a])		ln(grades 9-12 ADM[b])	
Independent variable	(1)	(2)	(3)	(4)
Four-day	-0.04		-0.02	
	(0.02)		(0.02)	
4+ year lead		0.00		-0.01
		(0.03)		(0.02)
3 year lead		-0.01		-0.00
		(0.03)		(0.03)
2 year lead		-0.02		-0.00
		(0.02)		(0.01)
Adoption year		-0.04		-0.02
		(0.03)		(0.03)
1 year lag		-0.06		-0.02
		(0.04)		(0.03)
2+ year lag		-0.05		-0.05
		(0.05)		(0.04)
N	4932	4932	3699	3699
Adj. R^2	0.9737	0.9737	0.9856	0.9856
p-value: $(H_0: \beta_{-2} = \beta_{-3} = \beta_{-4+} = 0)$	-	0.7168	-	0.9503
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.7412	-	0.5191

[a]Grades 9-12 enrollment data is from the CCD and represents districts' enrollments measured at a cross-sectional point in time each school year. These data are available from 2008 to 2019.
[b]Average Daily Membership (ADM) data is from the Oklahoma State Department of Education and represents districts' average daily enrollment over the course of a school year. Though ADM provides a more precise measure of enrollment than the CCD measure, these data are available only from 2011 to 2019.
Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE and year FE. The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule.
*p<.05, **p<.01, ***p<.001

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Appendix

Table A1: Effects of the Four-Day School Week on ACT Scores (Event Study)

	Dependent variables: ACT scores	
	Math ACT	English ACT
Independent variable	(1)	(4)
4+ year lead	0.29	0.05
	(0.20)	(0.23)
3 year lead	0.25	0.37
	(0.20)	(0.27)
2 year lead	0.12	-0.04
	(0.17)	(0.24)
Adoption year	0.16	-0.10
	(0.15)	(0.19)
1 year lag	0.57	0.43
	(0.29)	(0.32)
2+ year lag	0.52	0.31
	(0.31)	(0.35)
Adj. R^2	0.5465	0.6025
p-value: (H_0: $\beta_{-2} = \beta_{-3} = \beta_{-4+} = 0$)	0.4536	0.3680
p-value: (H_0: $\beta_0 = \beta_1 = \beta_{2+}$)	0.2693	0.1546

Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2008 to 2019, but 134 districts did not test students on the ACT or have missing data for at least one year. In total, ACT scores are not observed for 336 out of 4,932 district-year cells (N=4,596). Not testing students or having missing ACT data in a given year was not related to adopting a four-day school week (see Table 8). Schedule data and ACT data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).
*p<.05, **p<.01, ***p<.001

Table A2: Effects of the Four-Day School Week on Attendance Rates (Event Study)

	Dependent variables: Attendance rates[a]				
Independent variable	9th grade (1)	10th grade (2)	11th grade (3)	12th grade (4)	Total 9th-12th grades (5)
4+ year lead	0.046	0.113	-0.312	-0.115	-0.036
	(0.237)	(0.345)	(0.247)	(0.231)	(0.210)
3 year lead	-0.110	-0.153	-0.250	-0.143	-0.143
	(0.248)	(0.375)	(0.313)	(0.269)	(0.213)
2 year lead	0.089	0.319	-0.276	-0.189	-0.008
	(0.205)	(0.310)	(0.254)	(0.224)	(0.155)
Adoption year	0.042	0.025	-0.534	-0.203	-0.189
	(0.240)	(0.311)	(0.275)	(0.304)	(0.186)
1 year lag	0.218	0.145	-0.194	-0.429	-0.052
	(0.246)	(0.318)	(0.316)	(0.367)	(0.234)
2+ year lag	-0.345	0.034	-0.698*	-0.498	-0.386
	(0.248)	(0.340)	(0.301)	(0.333)	(0.224)
Adj. R^2	0.5385	0.5077	0.5088	0.5449	0.6615
p-value: $(H_0: \beta_{-2} = \beta_{-3} = \beta_{-4+} = 0)$	0.8377	0.3477	0.6193	0.8704	0.8032
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	0.0562	0.8414	0.1658	0.5382	0.2543

[a]Attendance rates are calculated using the following equation: Attendance rate = (Average Daily Attendance / Average Daily Membership) * 100. Point estimates can be interpreted as the percentage point change in attendance rate.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2011 to 2019 (N=3,699). Schedule data and attendance data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).

*p<.05, **p<.01, ***p<.001

Table A3: Effects of the Four-Day School Week on School Disciplinary Incidents (Event Study)

	Dependent variables: Incidents per pupil[a]						
	Alcohol, drugs, or tobacco	Vandalism	Bullying	Fighting or assault	Weapons	School bus	Truancy
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
4+ year lead	0.27	0.01	0.59	0.35	-0.12	-0.00	0.79
	(0.50)	(0.13)	(0.44)	(0.40)	(0.08)	(0.18)	(0.68)
3 year lead	-0.17	-0.00	0.64	0.32	-0.03	-0.08	0.43
	(0.53)	(0.13)	(0.46)	(0.46)	(0.09)	(0.17)	(0.65)
2 year lead	-0.17	-0.08	0.05	-0.06	-0.03	0.07	-0.39
	(0.42)	(0.13)	(0.29)	(0.40)	(0.10)	(0.25)	(0.51)
Adoption year	-0.36	-0.02	-0.29	-0.32	-0.12	-0.24	0.14
	(0.35)	(0.14)	(0.31)	(0.52)	(0.08)	(0.13)	(0.55)
1 year lag	-0.49	-0.02	0.03	-0.59	-0.07	-0.08	-0.03
	(0.40)	(0.16)	(0.26)	(0.45)	(0.09)	(0.14)	(0.51)
2+ year lag	0.15	-0.20	-0.41	-0.48	-0.07	-0.15	-0.44
	(0.56)	(0.14)	(0.33)	(0.56)	(0.10)	(0.17)	(0.65)
Adj. R^2	0.2850	0.0599	0.2025	0.2484	0.1163	0.1136	0.3379
p-value: $(H_0: \beta_{-2} = \beta_{-3} = \beta_{-4+} = 0)$	0.4492	0.7130	0.2966	0.3970	0.2649	0.9152	0.0899
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	0.1853	0.2049	0.3636	0.8646	0.7084	0.3929	0.6194

[a]Incidents per pupil are calculated using the following equation: Incidents per pupil = Incident count / Grades 9-12 enrollment.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2010 to 2018 (N=3,699). Schedule data and attendance data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).

*p<0.05, **p<.01, ***p<.001

Table A4: Effects of the Four-Day School Week on ACT Participation (Event Study)

	Dependent variables: ACT participation			
	Percent of students who take the ACT		District-level ACT sample missingness	
Independent variable	(1)	(2)	(3)	(4)
Four-day	-1.24		-0.01	
	(0.90)		(0.02)	
4+ year lead		-0.45		0.05
		(1.47)		(0.04)
3 year lead		2.79		0.03
		(2.47)		(0.04)
2 year lead		2.63		-0.00
		(1.59)		(0.04)
Adoption year		-1.12		0.03
		(1.16)		(0.03)
1 year lag		0.77		0.02
		(1.87)		(0.04)
2+ year lag		-0.09		0.01
		(1.61)		(0.04)
N	4590	4590	4932	4932
Adj. R^2	0.2407	0.2416	0.2577	0.2585
p-value: $(H_0: \beta_{-2} = \beta_{-3} = \beta_{-4+} = 0)$	-	0.1115	-	0.2913
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.4415	-	0.8475

Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2008 to 2019 (N=4,932), but 134 districts did not test students on the ACT or have missing data for at least one year. In total, ACT participation is not observed for 342 out of 4,932 district-year cells (N=4,590). Schedule data and ACT data are from the Oklahoma State Department of Education, and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).
*p<0.05, **p<.01, ***p<.001

Table A5: Effects of the Four-Day School Week on District Characteristics (Event Study)

	Dependent variables: District characteristics									
	% White		% Native American		% FRPL-eligible		% Special Education		Pupil-teacher ratio	
Independent variable	(1)	(2)	(3)	(4)	(7)	(8)	(9)	(10)	(11)	(12)
Four-day	1.52		-1.85		0.95		0.48		-0.32	
	(0.82)		(1.21)		(1.19)		(0.33)		(0.37)	
4+ year lead		-0.84		2.26		1.86		-0.65		-0.83
		(0.89)		(1.27)		(1.27)		(0.40)		(0.60)
3 year lead		-1.21		1.03		2.45		0.25		-0.41
		(0.75)		(0.88)		(1.26)		(0.33)		(0.66)
2 year lead		-0.47		-0.49		-0.06		-0.06		-0.56
		(0.51)		(0.59)		(1.12)		(0.42)		(0.60)
Adoption year		0.13		-0.37		2.58		-0.05		-1.01
		(0.67)		(0.93)		(1.40)		(0.34)		(0.60)
1 year lag		-0.11		-0.10		1.35		0.08		-1.19
		(0.77)		(1.08)		(1.72)		(0.39)		(0.64)
2+ year lag		1.42		-0.38		2.99		0.04		-0.76
		(1.15)		(1.59)		(1.90)		(0.42)		(0.67)
Adj. R^2	0.8799	0.8799	0.8902	0.8904	0.7516	0.7519	0.8443	0.8444	0.4073	0.4071
p-value: $(H_0: \beta_{-2} = \beta_{-3} = \beta_{-4+} = 0)$	-	0.4464	-	0.0935	-	0.0546	-	0.1123	-	0.2393
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.3106	-	0.8534	-	0.5530	-	0.8997	-	0.4345

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE and year FE. The panel data in this table include the 411 non-city districts serving high school students in Oklahoma that adopted a four-day school week between 2011 and 2019 or never had a four-day week schedule. The districts are observed annually from 2008 to 2019 (N=4,932). Schedule data are from the Oklahoma State Department of Education and demographic data are from the National Center for Education Statistics Common Core of Data (CCD).
*p<.05, **p<.01, ***p<.001

Table A6: Alternative Control Group Descriptive Statistics

	Treatment group				Alternative five-day week control groups			
	Four-day districts post-adoption (n=90)[a]		Four-day districts pre-adoption (n=90)[a]		Rural districts only (n=262)		Matched comparison group (n=90)	
District-level variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
District characteristics								
% FRPL-eligible	65.09	14.30	61.16	14.42	56.17	17.98	62.35	16.43
% ELL	1.63	2.00	1.35	4.19	2.17	5.13	0.85	2.08
% Special ed.	20.05	4.36	18.68	4.18	16.12	6.76	17.25	7.39
% White	56.40	16.75	58.41	17.54	62.66	17.07	58.85	17.20
% Native American	28.61	19.04	32.16	18.84	22.03	17.86	29.91	18.59
% Asian	0.50	0.76	0.50	0.61	0.68	1.34	0.57	1.17
% Hispanic	5.46	4.69	3.64	3.06	8.23	10.51	4.47	5.31
% Black	2.03	4.13	2.45	4.38	2.48	6.98	1.92	3.29
% Other	6.99	8.82	2.81	4.43	3.82	6.61	4.23	7.01
District HS enrollment	156.23	151.31	169.48	156.66	188.91	184.67	150.93	89.09
Pupil-teacher ratio	13.02	2.94	12.87	3.49	12.92	6.31	13.30	8.56
Location								
% Rural	94.57	22.55	94.17	20.78	100.00	0.00	94.63	22.55
% Town	3.21	17.41	4.10	17.38	0.00	0.00	3.61	18.67
% Suburb	2.22	14.82	1.73	12.00	0.00	0.00	1.76	13.15
% City	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACT participation and scores								
Participation (n)	33.05	29.65	30.45	37.02	40.66	73.52	33.86	80.49
English	16.77	1.06	18.14	1.70	18.34	1.76	17.99	1.60
Math	16.75	1.49	18.92	1.83	18.92	2.23	18.62	2.15
Attendance rates[b] (%)								
Grade 9	94.94	1.45	94.68	1.65	95.06	1.90	94.96	1.89
Grade 10	94.65	1.71	94.43	1.66	94.82	1.98	94.64	2.02
Grade 11	94.75	1.96	94.64	1.68	94.87	2.17	94.78	2.15
Grade 12	94.77	2.17	94.73	1.80	94.74	2.57	94.68	2.42
Incidents per student[c]								
Alcohol, drugs, or tobacco	2.09	2.40	2.83	2.29	2.10	2.69	2.42	3.08
Vandalism	0.25	0.50	0.37	0.60	0.22	0.88	0.24	1.19
Bullying	0.65	0.84	1.67	2.04	1.18	2.50	1.15	2.63
Fighting or assault	1.78	2.19	2.53	2.04	1.76	2.54	2.05	3.15
Weapons	0.17	0.34	0.26	0.33	0.26	0.66	0.30	0.65
School bus	0.26	0.58	0.48	0.68	0.33	0.95	0.32	0.94
Truancy	1.75	2.51	2.64	3.42	1.89	4.30	1.69	3.67

[a] Observations are weighted such that each pre- and post-adoption district is equally represented in their respective category, regardless of the year they adopted the four-day school week.
[b] Attendance rates are calculated by dividing districts' reported grades 9-12 Average Daily Attendance by grades 9-12 Average Daily Membership, and the data include district observations for 9 years, from spring 2011-2019.
[c] Incident data include district observations for 10 years, from spring 2010-2019.
Notes: The panel data in this table include the 411 non-city districts serving high school students in Oklahoma observed annually for 12 years (except as otherwise noted) from SY 2007-2008 to SY 2018-2019 (N=4,932). HS = high school. FRPL = Free or Reduced-Price Lunch. ELL = English language learners.

Table A7: Effects of the Four-Day School Week on ACT Scores Using Alternative Control Groups

	Dependent variables: ACT Scores			
	Math ACT		English ACT	
Independent variable	(1)	(2)	(3)	(4)
Panel A: Control group as rural five-day week districts				
Four-day	0.10		0.02	
	(0.17)		(0.18)	
Adoption year		-0.05		-0.16
		(0.14)		(0.16)
1 year lag		0.31		0.31
		(0.21)		(0.22)
2+ year lag		0.28		0.20
		(0.25)		(0.28)
Adj. R^2	0.5143	0.5150	0.5729	0.5733
p-value: (H_0: $\beta_0 = \beta_1 = \beta_{2+}$)	-	0.3705	-	0.2172
Panel B: Control group as the matched comparison group				
Four-day	0.08		0.07	
	(0.17)		(0.19)	
Adoption year		0.01		-0.06
		(0.14)		(0.16)
1 year lag		0.24		0.33
		(0.23)		(0.23)
2+ year lag		0.28		0.28
		(0.28)		(0.30)
Adj. R^2	0.4641	0.4647	0.5508	0.5514
p-value: (H_0: $\beta_0 = \beta_1 = \beta_{2+}$)	-	0.6545	-	0.3799

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The data in Panel A include a panel of the 90 treated districts and 262 control districts observed annually from 2008-2019 (N=4,224), and the data in Panel B include a panel of the 90 treated districts and 90 control districts observed annually from 2008-2019 (N=2,160).
*p<0.05, **p<.01, ***p<.001

Table A8: Effects of the Four-Day School Week on Attendance Rates Using Alternative Control Groups

	Dependent variables: Attendance rates[a]									
	9th grade		10th grade		11th grade		12th grade		Total 9th-12th grade	
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Control group as rural five-day week districts										
Four-day	0.01		-0.10		-0.23		-0.13		-0.13	
	(0.17)		(0.21)		(0.22)		(0.23)		(0.17)	
Adoption year		0.07		-0.04		-0.33		-0.10		-0.13
		(0.21)		(0.23)		(0.25)		(0.27)		(0.19)
1 year lag		0.28		0.13		0.04		-0.30		0.04
		(0.20)		(0.23)		(0.27)		(0.34)		(0.21)
2+ year lag		-0.27		0.03		-0.51		-0.38		-0.30
		(0.26)		(0.29)		(0.29)		(0.33)		(0.23)
Adj. R^2	0.4955	0.4966	0.4573	0.4568	0.4580	0.4585	0.5085	0.5085	0.6294	0.6295
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.0684	-	0.7187	-	0.1158	-	0.5864	-	0.2042
Panel B: Control group as the matched comparison group										
Four-day	0.10		-0.03		-0.18		0.04		-0.03	
	(0.19)		(0.23)		(0.24)		(0.23)		(0.18)	
Adoption year		0.19		0.02		-0.25		0.00		-0.04
		(0.24)		(0.25)		(0.27)		(0.27)		(0.20)
1 year lag		0.35		0.25		0.03		-0.11		0.14
		(0.23)		(0.25)		(0.28)		(0.33)		(0.22)
2+ year lag		-0.13		0.17		-0.50		-0.20		-0.17
		(0.30)		(0.32)		(0.32)		(0.35)		(0.26)
Adj. R^2	0.4375	0.4392	0.4171	0.4167	0.4250	0.4257	0.4816	0.4810	0.5926	0.5928
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.1345	-	0.5765	-	0.1875	-	0.7922	-	0.2372

[a]Attendance rates are calculated using the following equation: Attendance rate = (Average Daily Attendance / Average Daily Membership) * 100. Point estimates can be interpreted as the percentage point change in attendance rate.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The data in Panel A include a panel of the 90 treated districts and 262 control districts observed annually from 2011-2019 (N=3,168), and the data in Panel B include a panel of the 90 treated districts and 90 control districts observed annually from 2011-2019 (N=1,620).

*p<0.05, **p<.01, ***p<.001

Table A9: Effects of the Four-Day School Week on Disciplinary Incidents Per Pupil Using Alternative Control Groups

	Dependent variables: Incidents per pupil[a]													
	Alcohol, drugs, or tobacco		Vandalism		Bullying		Fighting or assault		Weapons		School bus		Truancy	
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Panel A: Control group as rural five-day week districts														
Four-day	-0.42		-0.04		-0.48*		-0.75**		-0.01		-0.10		-0.29	
	(0.31)		(0.09)		(0.23)		(0.25)		(0.06)		(0.08)		(0.39)	
Adoption year		-0.35		-0.02		-0.61*		-0.58		-0.07		-0.24*		-0.14
		(0.38)		(0.09)		(0.29)		(0.44)		(0.07)		(0.12)		(0.45)
1 year lag		-0.48		-0.01		-0.26		-0.81*		-0.03		-0.05		-0.41
		(0.37)		(0.14)		(0.29)		(0.36)		(0.08)		(0.11)		(0.47)
2+ year lag		0.24		-0.21		-0.57		-0.77		-0.04		-0.13		-0.75
		(0.52)		(0.11)		(0.33)		(0.46)		(0.09)		(0.14)		(0.60)
Adj. R^2	0.2750	0.2752	0.0591	0.0594	0.1933	0.1928	0.2457	0.2446	0.1016	0.1011	0.1055	0.1056	0.3516	0.3514
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.1314	-	0.1769	-	0.4402	-	0.9287	-	0.8540	-	0.3517	-	0.5166
Panel B: Control group as the matched comparison group														
Four-day	-0.27		-0.01		-0.44*		-0.54*		-0.03		-0.15		-0.35	
	(0.33)		(0.10)		(0.23)		(0.27)		(0.06)		(0.08)		(0.41)	
Adoption year		-0.16		0.00		-0.52		-0.43		-0.09		-0.27*		-0.21
		(0.39)		(0.10)		(0.29)		(0.45)		(0.07)		(0.11)		(0.46)
1 year lag		-0.25		0.02		-0.31		-0.47		-0.06		-0.14		-0.56
		(0.40)		(0.15)		(0.30)		(0.38)		(0.09)		(0.12)		(0.51)
2+ year lag		0.66		-0.18		-0.55		-0.41		-0.11		-0.22		-0.89
		(0.56)		(0.12)		(0.36)		(0.51)		(0.10)		(0.15)		(0.64)
Adj. R^2	0.2606	0.2622	0.0377	0.0376	0.1935	0.1922	0.2321	0.2302	0.0908	0.0905	0.1098	0.1098	0.2112	0.2109
p-value: $(H_0: \beta_0 = \beta_1 = \beta_{2+})$	-	0.0538	-	0.1910	-	0.7220	-	0.9834	-	0.8347	-	0.6220	-	0.4729

[a]Incidents per pupil are calculated using the following equation: Incidents per pupil = Incident count / Grades 9-12 enrollment.

Notes: Standard errors, clustered at the district level, are in parentheses. All models include district FE, year FE, and the following district-level covariates: the percent of students eligible to receive free or reduced-price lunch, the percent of English learners, and the percent of special education students (coefficients suppressed). The data in Panel A include a panel of the 90 treated districts and 262 control districts observed annually from 2010-2018 (N=3,168), and the data in Panel B include a panel of the 90 treated districts and 90 control districts observed annually from 2010-2018 (N=1,620).

*p<0.05, **p<.01, ***p<.001

Figure A1: Timing of Four-Day School Week Adoption in Oklahoma

(a) Number of Oklahoma districts with four-day weeks by year (spring)

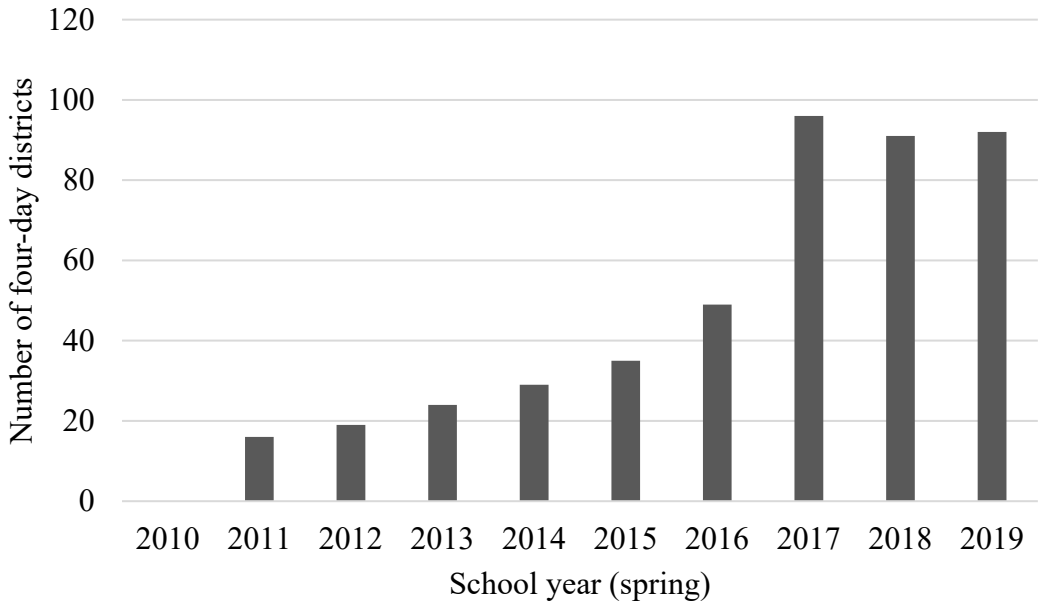
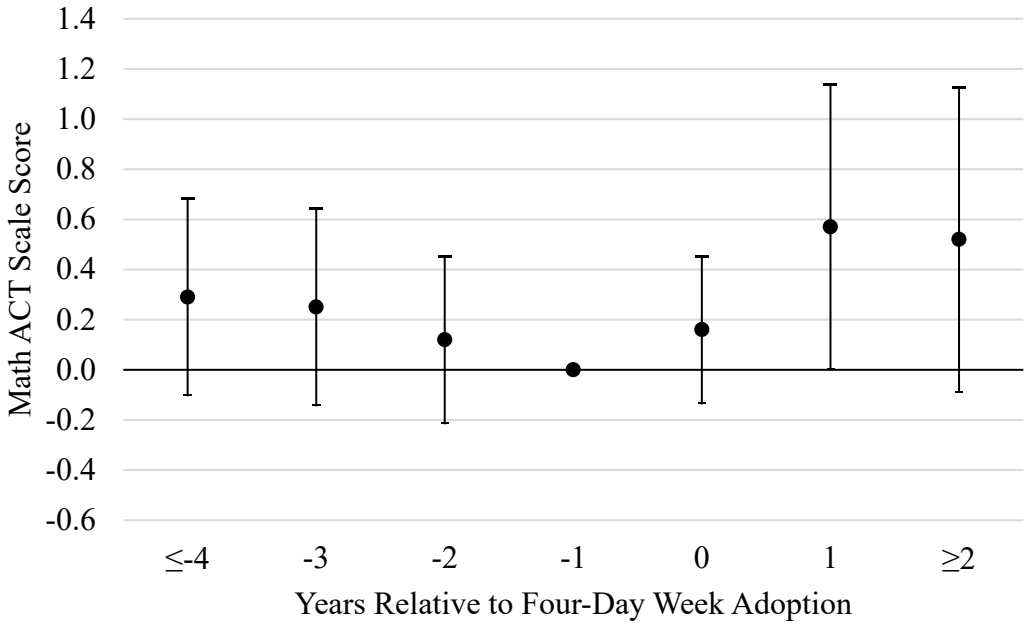


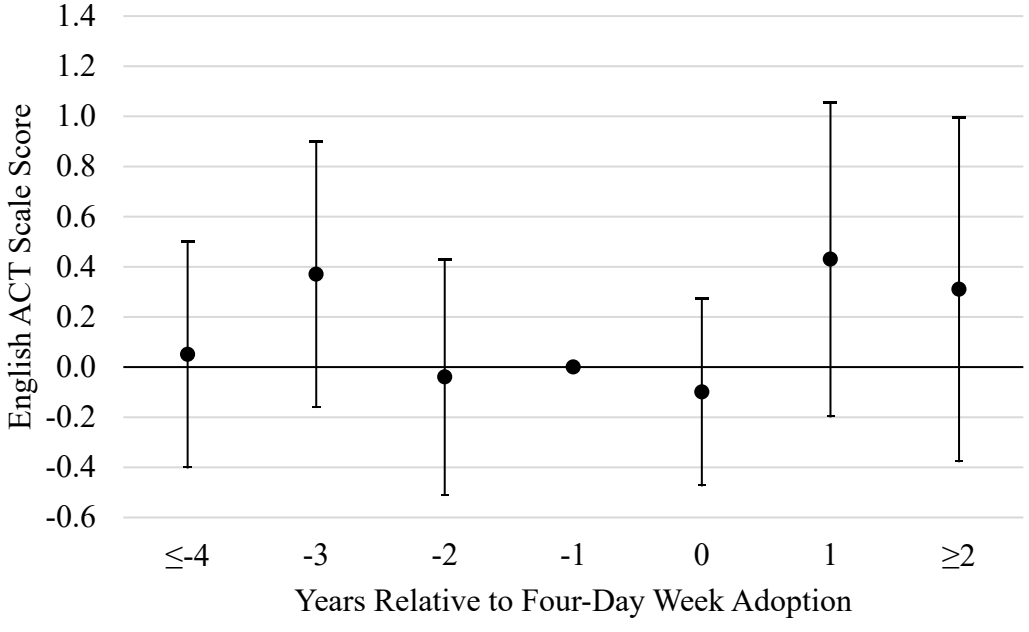
Figure A2: Effects of the Four-Day School Week on ACT Scores (Event Study)

(a) Math ACT Scores



Error bars: 95% CI

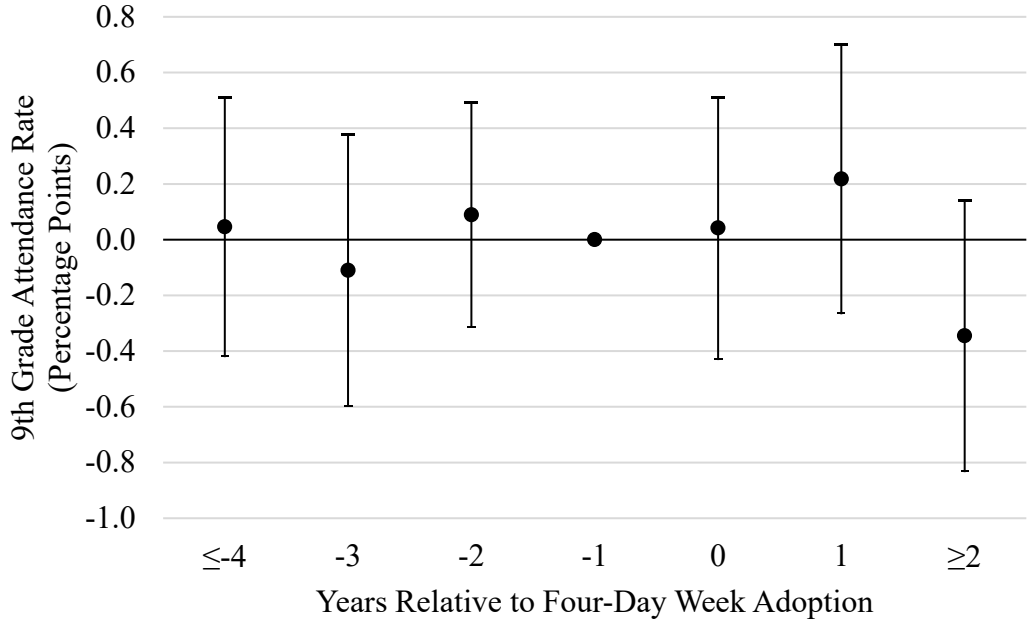
(b) English ACT Scores



Error bars: 95% CI

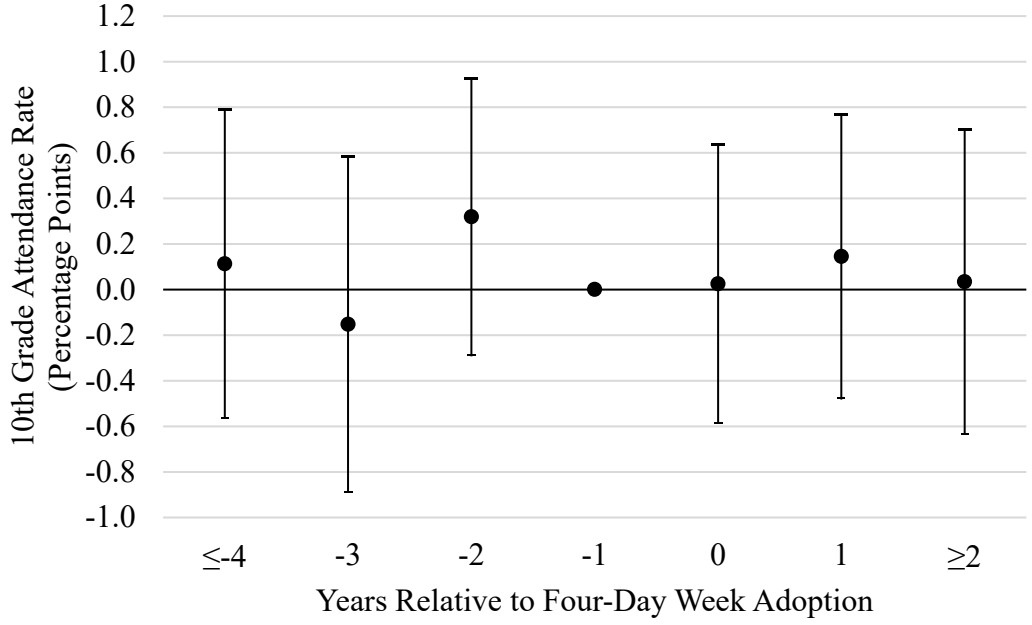
Figure A3: Effects of the Four-Day School Week on Attendance (Event Study)

(a) 9th Grade



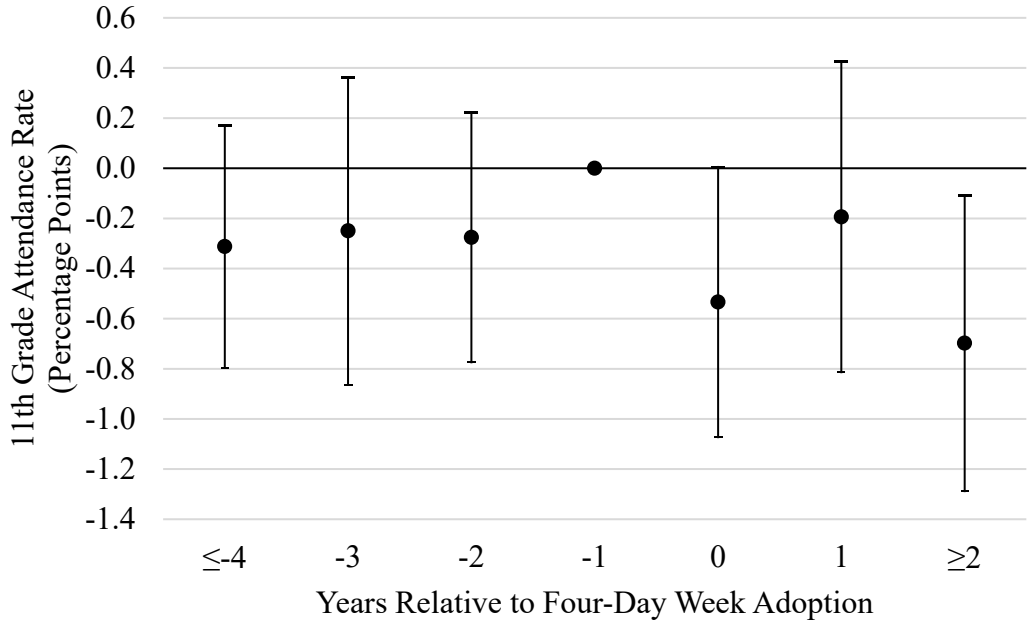
Error bars: 95% CI

(b) 10th Grade



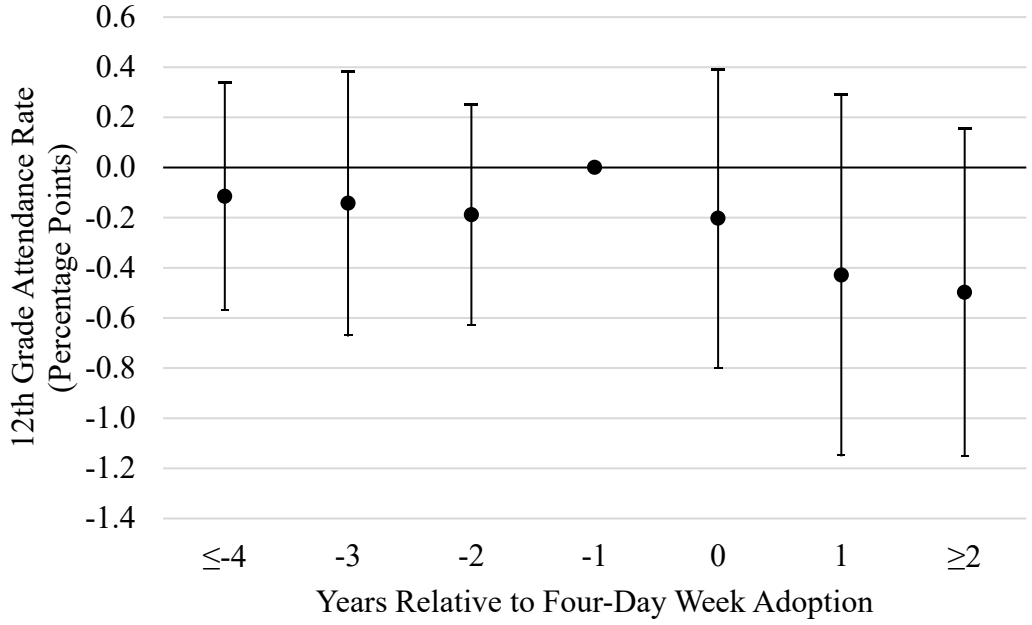
Error bars: 95% CI

(c) 11th Grade



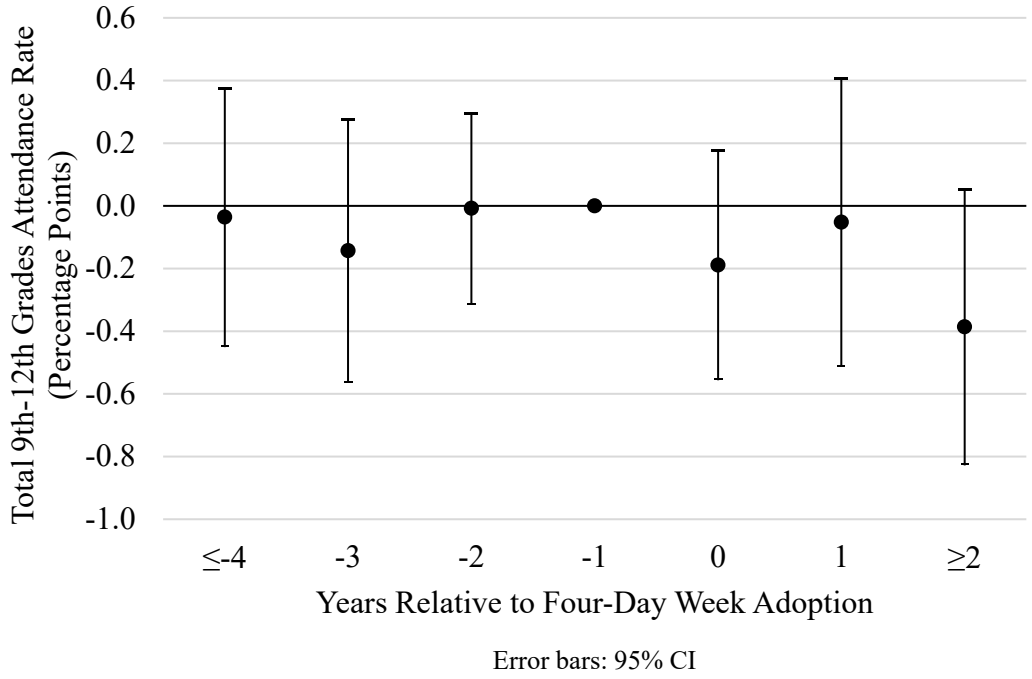
Error bars: 95% CI

(d) 12th Grade



Error bars: 95% CI

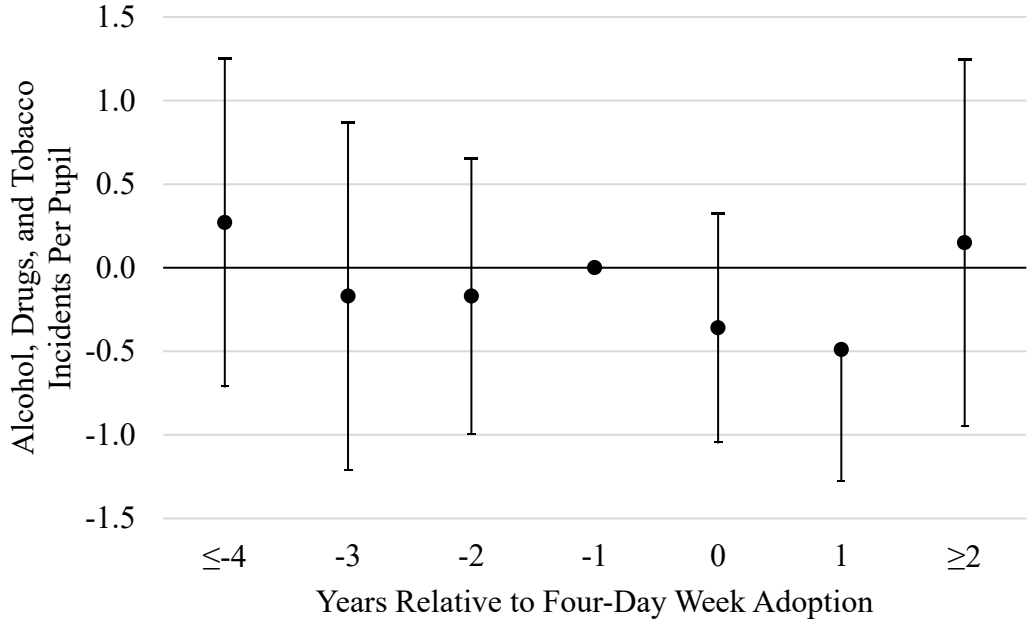
(e) Total 9th-12th Grades



Error bars: 95% CI

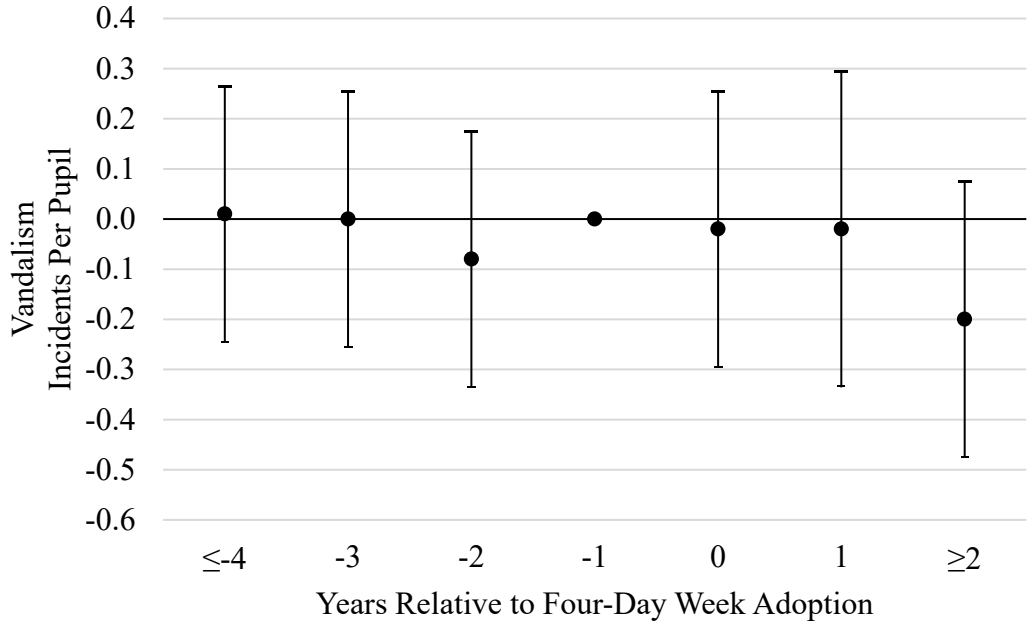
Figure A4: Effects of the Four-Day School Week on School Disciplinary Incidents Per Pupil (Event Study)

(a) Alcohol, Drugs, and Tobacco Incidents Per Pupil



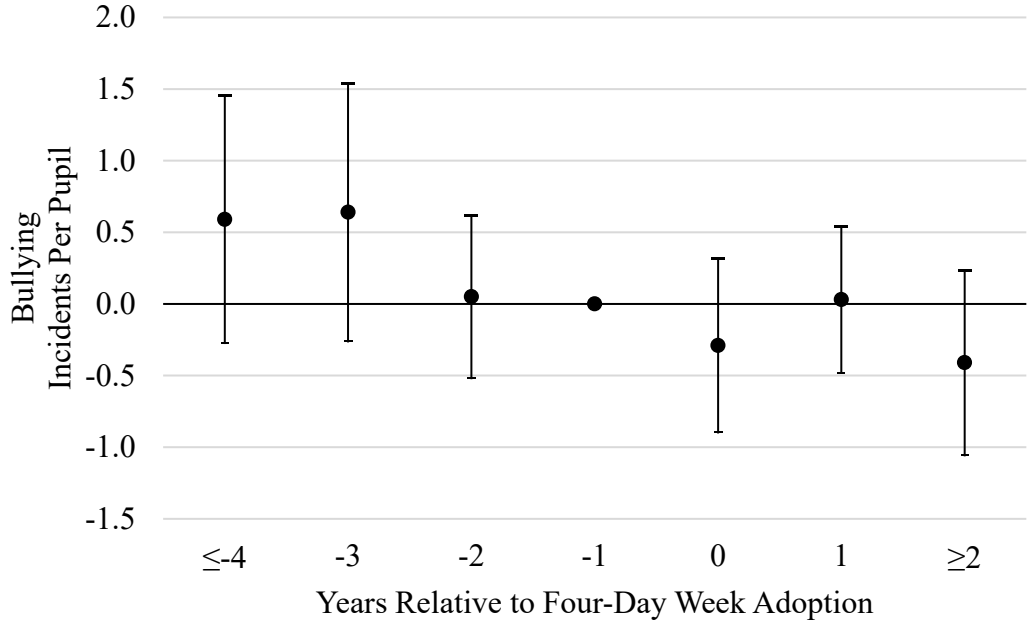
Error bars: 95% CI

(b) Vandalism Incidents Per Pupil



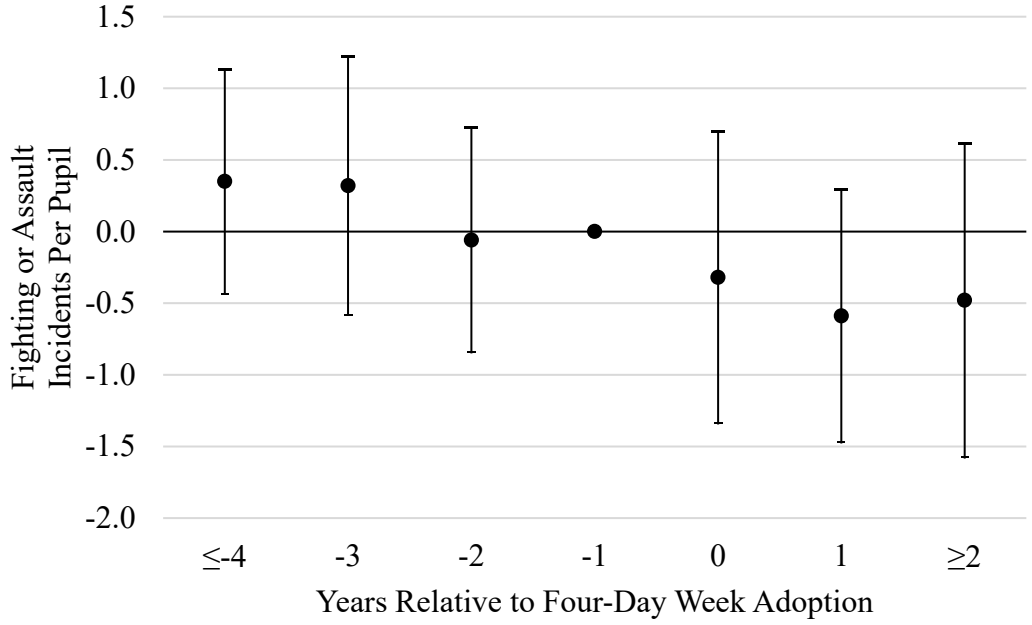
Error bars: 95% CI

(c) Bullying Incidents Per Pupil



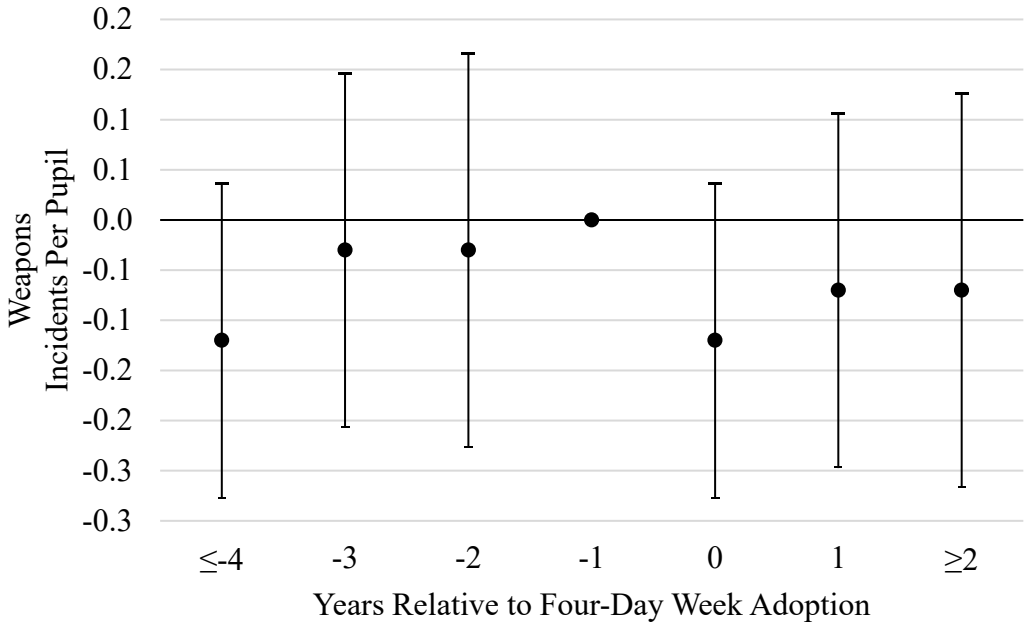
Error bars: 95% CI

(d) Fighting or Assault Incidents Per Pupil



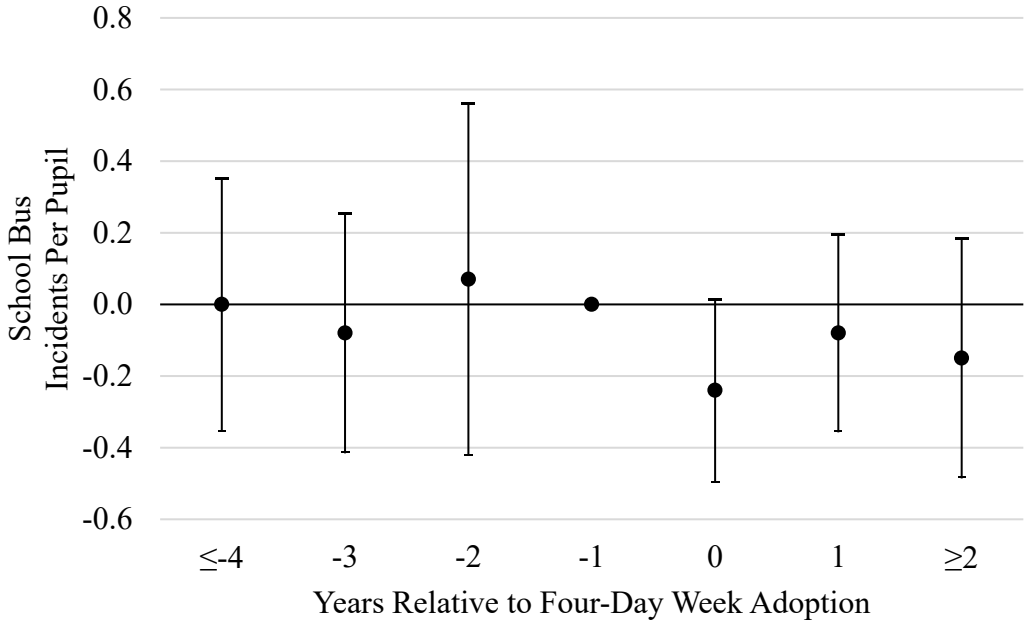
Error bars: 95% CI

(e) Weapons Incidents Per Pupil



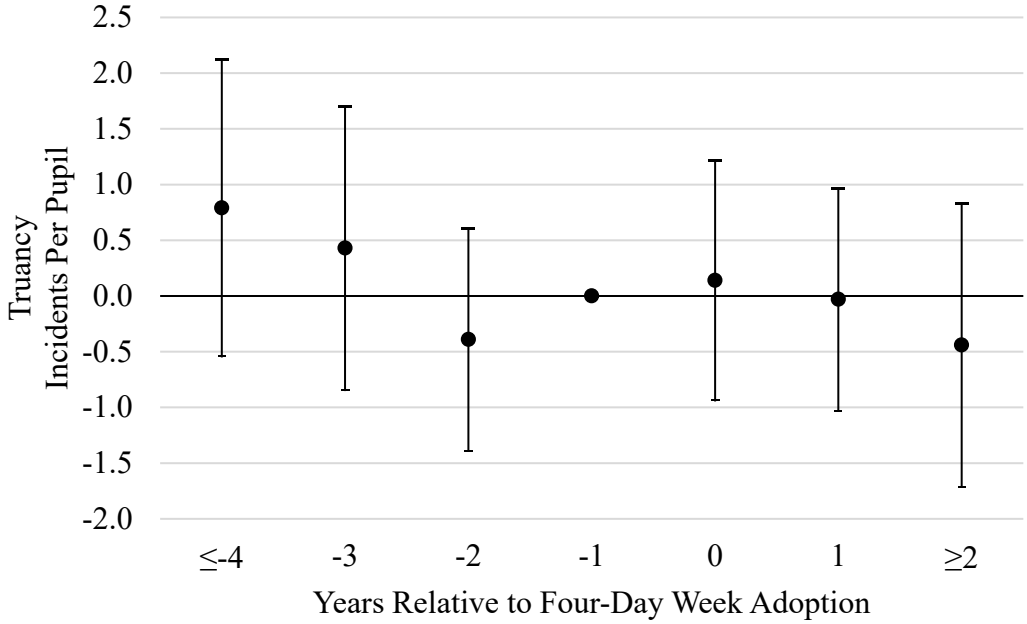
Error bars: 95% CI

(f) School Bus Incidents Per Pupil



Error bars: 95% CI

(g) Truancy Incidents Per Pupil



Error bars: 95% CI