Impacts of Four-Day School Weeks on Teacher Recruitment and Retention and Student Attendance: Evidence from Colorado

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Abstract

Four-day school week (4DSW) schedules are growing rapidly across the U.S., with school districts citing perceived benefits to teacher recruitment and retention and student attendance as motivations for adopting the schedule. This study uses panel data from Colorado, one of the states with the highest prevalence of 4DSWs, to investigate the impacts of the 4DSWs on the percentage of teachers with shortage credentials, teacher attrition rates, and student attendance rates. Utilizing a synthetic control difference-in-differences research design, we find 4DSWs have small negative or statistically insignificant effects on teacher recruitment and retention outcomes and find little variation in these effects by school rurality. Examining student attendance outcomes, we estimate a meaningfully small 0.76 percentage point reduction in attendance rates associated with adopting a 4DSW in non-rural schools (equivalent to 46% of these schools' typical yearly fluctuations in ADA) but do not detect an effect in small rural or non-rural schools. These findings suggest that these purported benefits of 4DSWs are not realized in Colorado, warranting concern about the continued use and expansion of this schedule given prior evidence of its negative average impacts on student achievement.

1. Introduction

Four-day school week (4DSW) schedules have become increasingly popular in the U.S. over the last several years. As of the 2022-23 school year, nearly 900 school districts across 26 states have adopted the schedule, a sharp increase from the 650 districts operating on the schedule in 2019-20 (Thompson, 2023, as cited in Cook, 2023). Besides a few recent adoptions by suburban schools, 4DSWs are largely implemented by small, rural schools. Schools cite a variety of reasons for adopting the schedule, including cost savings, student attendance, and concerns about teacher burnout and turnover, but there is conflicting evidence on whether the schedule is having its intended impacts on student attendance and staffing. The recent proliferation of the schedule has been contentious, with many states worrying about negative impacts on student outcomes and considering legislation that would prevent or limit the use of 4DSWs (e.g., Egbuonu, 2024; Martinez-Keel, 2024; Sago & Bayless, 2024) despite the high levels of satisfaction with the schedule in 4DSW schools (Kilburn et al., 2021).

The present study examines impacts of the 4DSW in the context of Colorado, a state with some of the earliest adoptions and most sustained and prolific growth in 4DSWs over the past two decades. We build on previous research on effects of 4DSWs to analyze the impacts of adopting the schedule on teacher recruitment and retention outcomes and on student attendance rates. More specifically, we leverage a synthetic control difference-in-differences research design and longitudinal data from Colorado on staffing, school calendars, student attendance, and school demographics to estimate these impacts. In the following sections, we review the national evidence on the motivation for adopting 4DSWs over time, the policy context of school calendars and teacher shortages in Colorado, existing evidence on rural teacher labor markets, the effects of working condition policies on teacher recruitment and retention outcomes, and what is known about the effects of 4DSWs on student attendance.

This study makes a significant contribution to the existing research on the impacts of 4DSWs, providing the first analysis of impacts of the schedule on staffing and student attendance in Colorado. The existing research on effects of 4DSWs has primarily examined outcomes related to cost savings, student achievement, student behavior, and student attendance. Finance studies find that the 4DSW does cut costs, but the average cost savings are minimal (Morton, 2021; Thompson, 2021a). Whereas studies of student achievement consistently find the schedule has negative average impacts on test scores (~-0.02 to -0.09 SD; Morton et al., 2023), the research on student behavior shows the schedule decreases rates of bullying and fighting during school but increases delinquency outside of school (Fischer & Argyle, 2018; Morton, 2023). Studies of student attendance generally fail to detect effects on average daily attendance rates (Kilburn et al., 2021; Morton, 2023; Thompson, 2021b). Evidence on policies that may positively influence teacher recruitment and retention outcomes and student attendance is particularly important in the context of the postpandemic historically low levels of teacher job satisfaction and rising rates of student absenteeism (Dee, 2024; Kraft & Lyon, 2022). Given the mixed positive and negative impacts of the 4DSW to date and the challenges schools are facing related to staffing and student attendance in the postpandemic education climate, evidence on the schedule's impacts on these outcomes will help to fill gaps in our knowledge about the tradeoffs of the policy and can improve policymakers' and practitioners' ability to make evidence-based decisions about the policy. Colorado provides an opportune setting for examining these impacts, with some of the most and longest-running four-day school weeks in the U.S.

1.1 Motivations for adopting the 4DSW

There are many reasons that schools and districts have adopted 4DSWs, among which the most common are expected cost savings, improvements in student attendance, and increases in

student and teacher retention (Thompson et al., 2021a). Thompson et al.'s (2021a) 2018-19 national survey of 4DSW districts found the most common reason for adopting a 4DSW was anticipated cost savings (65% of districts selected finances as part of their motivation). While 4DSWs enable districts to cut some costs on transportation, operations, and food services, evidence indicates average total savings are small, around 1-2% of a district's budget (Morton, 2021; Thompson, 2021a). About 29% of the surveyed districts selected any attendance-related issues, including those related to absences (14%), appointments (8%) and athletics (19%), as part of their reasoning for adopting the schedule. Nevertheless, as discussed in more detail below, the existing evidence finds no impact or negligible effects of adopting the schedule on student Average Daily Attendance (ADA) rates. In Thompson et al.'s (2021a) prepandemic survey, 15% of districts selected "student/teacher" retention as a reason they adopted the schedule.

In the years following the pandemic-related school closures, however, anecdotal reports strongly suggest the primary rationale for adopting 4DSWs has shifted to concerns about teacher shortages (e.g., Egbuonu, 2024; Martinez-Keel, 2024; Sago & Bayless, 2024). Teacher shortages, though often discussed in the aggregate, are a highly localized phenomenon and tend to be greater in rural areas (Edwards et al., 2023). Simplistically, shortages are driven by two main factors: the rate at which teachers leave the district (i.e., teacher turnover) and the rate at which districts fill open positions with qualified teachers. Teacher turnover rates are broadly similar across rural, suburban, and urban schools (Donaldson, 2010; Nguyen et al., 2020; Smith, 2006), but it is noteworthy that high-poverty rural schools and rural schools with high percentages of students of color have the highest turnover rates across the U.S., 28% and 32% respectively (Ingersoll & Tran, 2023). The drivers of district turnover also vary by locale; in rural areas, turnover is driven by high rates of pre-retirement turnover and movement to

suburban or urban schools, rather than by retirement (Ingersoll & Tran, 2023). Rural and urban districts also have more difficulty filling open positions with qualified teachers than their suburban and town counterparts (Cowan et al., 2016; Jacob, 2007; McVey & Trinidad, 2019). Extensive research suggests the increased rates of shortages and turnover in rural districts are likely to have adverse effects on the quality of instruction and student learning outcomes (Clotfelter, Ladd & Vigdor, 2010; Kuhfeld, Soland & Lewis, 2022; Krueger & Whitmore, 2001; Ronfeldt, Loeb & Wycoff, 2013; Wedel, 2021).

1.2 Reduced academic calendar policy and implementation in Colorado

Policies enabling 4DSWs in Colorado date to 1980, when the state legislature allowed three districts to pilot the schedule. Shortly thereafter, in 1985, the legislature universally allowed 4DSWs by changing the mandated minimum amount of instruction per year from 180 days to 1080 hours. Beginning in 1990, districts that planned to operate for fewer than 160 days, including nearly all 4DSW calendars, were required to apply for a waiver from CDE.[1] Since then, districts who submit applications can operate for fewer than 160 days, as long as they meet the required minimum hours of instruction—900 hours for kindergarten students, 990 hours for older elementary students and 1080 hours for students in middle school and beyond.[2] In practice, a middle school that used to have 6 hours of instruction per day for 180 days would need to increase their instructional time per day by 1 hour and 18 minutes if they wanted to reduce their schedule to 148 school days (the average number of days on a 4DSW reported by Thompson et al. (2021a)). The different types of school time (e.g., study hall, passing time, parent-teacher conferences, teacher professional development) included in "instructional hours" in Colorado are

[1] CDE has authority to approve or deny waiver applications, but CDE personnel are not aware of any applications that have been denied to date.
[2] See Colorado Revised Statute 22-32-109.

defined by each local school board, though the State Board requires that time for lunch is not counted as instructional time.[3]

Colorado has seen some of the earliest and most prolific growth in reduced academic calendars[4] (i.e., 4DSWs), jumping from just under 50 districts with at least one school operating on the schedule in 1998-99 (Thompson et al., 2021a) to 126 districts (71% of Colorado's 179 public school districts) and 1 Board of Cooperative Educational Services (BOCES)-operated school (of 14 schools run by the 6 BOCES in Colorado) in 2022-23 (see Table 1 and Figure 1 for more information about the growth of reduced academic calendars in Colorado over time).

In Colorado, like the broader U.S., small and rural districts are disproportionately likely to adopt 4DSWs (Morton et al., 2024). Specifically, Colorado districts that have ever had a school operating on the schedule include 98 of Colorado's 110 small rural districts that serve fewer than 1,000 students, 17 of Colorado's 38 rural districts that serve between 1,000 and 6,500 students, and 11 of Colorado's 32 non-rural districts. Altogether, 4DSW schools served about 12% of Colorado K-12 public school students in 2022-23.

As noted previously, Thompson et al.'s (2021a) national survey of 4DSW districts found the most common rationale (65%) for adopting the schedule through 2018-19 was cost savings. This was also true of 4DSW districts in Colorado (67% said financial reasons were a main reason they switched from a five-day week), though Colorado adopters were more likely (24%) than the national sample (15%) to also cite "student/teacher retention" as one of the main reasons they switched. About 19% of the surveyed Colorado districts identified attendance issues as a reason

[3] See Colorado State Board Rule 1 CCR 301-39.wav

[4] The Colorado State Department of Education (CDE) does not officially track whether schools implement a 4DSW when they operate on a reduced academic calendar of fewer than 160 days. We reviewed calendars posted on school websites for a sample (50%) of the schools with a reduced calendar waiver in 2023-24 and found all of these schools were operationalizing their reduced academic calendar as a 4DSW. Therefore, we assume in this study that all schools that have a reduced academic calendar waiver are operating on a 4DSW.

for the switch. In the years since the pandemic, however, anecdotal evidence (e.g., Heubeck, 2022) suggests teacher recruitment and retention have become the primary rationale for adopting 4DSWs in Colorado.

For teachers in Colorado 4DSW districts, results from the same 2018-19 survey suggest the "off day" is largely a day off, as 48% of districts reported their buildings were closed and did not offer academic activities, though 27% reported at least some off days were used for professional development, and 30% reported some off days were used for student enrichment opportunities or remedial instruction programs (Thompson et al., 2021a). Though there is variation in the reported use of the off day across states, the Colorado results were generally consistent with the national results. The Colorado results are also consistent with Kilburn et al.'s (2021) interviews of 4DSW teachers in Idaho, New Mexico, and Oklahoma, during which they described using the day as a personal day, to spend time with family, to supplement their income, to grade student assignments, and/or to prepare for the next week(s) of teaching.

1.3 Teacher shortages and student attendance rates in Colorado

Consistent with anecdotal accounts of teacher burnout and shortages in the wake of the pandemic (e.g., Barnum, 2023), there is now robust evidence that teacher turnover rates and shortages, defined as the number of teacher vacancies unfilled or filled by shortage mechanisms (i.e., long-term substitute teachers, retired educators, alternative licensure program candidates, and emergency authorization candidates), have increased (Goldhaber & Theobald, 2022; Nguyen et al., 2022, 2024). The best recent evidence on shortages in Colorado comes from the CDE's Educator Shortage Survey administered annually to all school districts. The results of the 2022-23 survey show that Colorado public schools hired for 8,284 teaching positions (15.0% of all positions), with 722 of these positions (1.3% of all positions) remaining unfilled for the entire

year and 1,486 (2.7% of all positions) filled using a shortage mechanism, resulting in an overall teacher shortage rate across all Colorado teaching positions of 4.0% (Colorado Department of Education, 2023). This rate is an increase from the 2021-22 Colorado shortage rate of 2.8% but is below the average state-level shortage rate in the U.S., which was approximately 7% in 2021-22 (Nguyen et al., 2022, 2024). Like other states, Colorado's shortages are disproportionately concentrated in special education (SPED), STEM, and CTE teaching roles (Cowan et al., 2016; Edwards et al., 2024; Theobald et al., 2023).

Shortages are even more acute in Colorado's small rural districts, where 11.7% of teaching roles were filled using a shortage mechanism and 2.8% of positions remained unfilled (Colorado Department of Education, 2023). Larger rural districts were a bit better off, with 5.0% of roles filled using shortage mechanisms and 1.2% remaining unfilled for the year. Meanwhile, non-rural districts had just 1.7% of teachers filled by shortage mechanisms and 1.2% of roles unfilled. Shortages in rural districts are also more pronounced for SPED, STEM, and CTE positions, but shortages in nearly all subject areas in rural districts (and especially in small rural districts) are larger than the worst shortages in urban districts. Both rural and non-rural districts relied most on alternative licensure program candidates to fill vacancies, filling about a third of their total vacancies with these candidates. However, rural districts filled over 60% of the remaining roles with retired teachers and long-term substitutes, whereas non-rural districts filled only 30% of the remaining roles from these two groups and were more likely to have positions that remained unfilled for the year.

Publicly available data[5] indicates teacher turnover (i.e., attrition) rates in Colorado, however, have both historically and recently been high relative to national averages. In the years

[5] These data are made available online by CDE at https://www.cde.state.co.us/cdereval/rvprioryearhrdata.

leading up to the pandemic, teacher turnover hovered around 18-19% in Colorado, notably higher than the national prepandemic rate of about 16% (Carver-Thomas & Darling-Hammond, 2017). Following the pandemic, in 2021-22,[6] turnover rates increased in Colorado and across the U.S. by a similar amount, about 3-4 percentage points (Diliberti & Schwartz, 2023; Nguyen et al., 2024). As displayed in Figure 2, Colorado's small rural districts have had the highest rates of teacher turnover in the state both pre- and post-pandemic, roughly 2-3 percentage points higher than that of rural and non-rural districts over time. As of 2022-23, the turnover rate in small rural districts was at an alarming historic high of 22.5%.

Student attendance rates in Colorado have declined over the past two decades, dropping from 93.8% in 2008-09 to 90.6% in 2022-23. As displayed in Figure 3, declines have been greatest in non-rural districts, followed by those in large rural districts, then those in small rural districts. As of 2022-23, non-rural districts had an average ADA of just 90.1%, while large rural districts' ADA was 91.5% and small rural districts' ADA was 92.2%. These declines comport with those seen across the U.S. in the wake of the pandemic, as a survey of a representative set of U.S. schools reported the average ADA rate as of November 2023 was 90% (National Center for Education Statistics, 2024). Though these changes may seem small, the relative stability of average ADA rates across U.S. public schools prior to the pandemic, ranging from 93% to 95%, indicates these declines are atypical and alarming. Aligned with these findings, Colorado has experienced similar increases in chronic absenteeism (i.e., being absent for 10% or more of enrolled school days) as the U.S., increasing from 24.3% of Colorado students in 2016-17 to 31.1% in 2022-23 (Dee, 2024; Colorado Department of Education, 2024).

[6] In this paper, teacher turnover in a given year (e.g., 2021-22) refers to the teachers who were working in a district during the prior school year (e.g., 2020-21) but were no longer working in that district as of fall of the next school year (e.g., fall 2021).

CDE's focus on reducing teacher shortages,[7] turnover rates, and student absenteeism (Córdova, 2024) is warranted, as a substantial body of literature indicates that these factors are associated with negative student outcomes. For example, recent evidence on expanded emergency licensure in MA in response to COVID-19 finds these teachers are less effective at improving student test scores than teachers with alternative or traditional credentials (Backes et al., 2024). The evidence on the impacts of teachers with alternative licenses on student outcomes is somewhat mixed (Clotfelter et al., 2007; Clotfelter et al., 2010; Goldhaber, 2007), with studies of highly selective alternative preparation programs (e.g., Teach for America) finding these teachers are no less effective at raising student achievement, but they are more likely to turnover (e.g., Boyd et al., 2010; Buddin & Zamarro, 2008; Carver-Thomas & Darling-Hammond, 2017; Goldhaber & Brewer, 2000). Extensive research shows high rates of teacher turnover are decidedly harmful for student achievement[8] (e.g., Carver-Thomas & Darling-Hammond, 2017; Hanushek et al., 2016; Henry & Redding, 2020; Ronfeldt et al., 2013). Finally, there is also robust evidence that student absences are harmful for student achievement,[9] as well as other important student outcomes such as on-time graduation and college enrollment (e.g., Aucejo & Romano, 2016; Goodman, 2014; Liu et al., 2021).

[7] A shortage credential (i.e., an alternative license or an emergency authorization license) typically implies the teacher does not yet hold a traditional teaching license in the state and is working to complete the necessary teacher preparation to receive their license while they are teaching. These licenses are meant to be temporary solutions to shortages, and they are typically approved for only one or two years.

[8] Ronfeldt et al. (2013) estimate that, relative to no turnover, 100% turnover in a given grade causes students in that grade the following year to score 0.08-0.10 SD lower in math and 0.05 SD lower in ELA. These sizeable effects are even larger in schools that serve higher proportions of low-performing students and Black students. The negative effects are also larger when a teacher leaves during the school year as opposed to between years (Henry & Redding, 2020).

[9] For instance, Liu et al. (2021) find 10 absences in middle and high school reduces standardized test scores in math and ELA by 0.03-0.04 SD.

1.4 Effects of 4DSWs on teacher recruitment and retention

Districts claim 4DSWs help them both to attract and retain teachers (Heubeck, 2022), but there is limited and conflicting empirical evidence regarding this claim. In interviews, most district leaders and teachers said they prefer the schedule because it reduces the number of hours they are required to be at the school building and affords them more flexibility with their time (Kilburn et al., 2024). Teachers reported using their time in a variety of ways on the fifth day, including but not limited to working another job, spending time with family, prepping for classes and grading, coaching school athletics teams, district-led professional development, and/or attending personal appointments. While these interview findings are informative regarding the potential mechanisms that could be underlying any positive impacts of 4DSWs on recruitment and retention outcomes, causal, quantitative analyses are necessary for estimating the average effects of the schedule.

Manion and Varkey (2021) use longitudinal data from Missouri, where 102 districts (20%) operated on a 4DSW as of 2020-21, to estimate the effect of adopting the schedule on teacher shortages as measured by the percentage of vacancies filled with fully qualified applicants in each district. They find 4DSWs improve this recruitment outcome only in rural districts (by four percentage points), whereas 4DSWs in town districts have no detectable effect. Using data from Arkansas where 32 districts (13%) had a 4DSW as of 2023-24, Camp (2024) finds the schedule significantly decreases the probability that a teacher moves to another district by 1.4 percentage points but does not detect an effect on teachers' likelihood to exit the teaching profession (or the state). Alternatively, Nowak et al. (2023) find that adopting the schedule in one district in Colorado decreased the district's overall retention rate by 5 percentage points. It is difficult to know how these findings apply to the average 4DSW, especially over time, because

the majority of Arkansas districts with 4DSWs adopted the schedule in the last three years (i.e., since the pandemic), and the district in Nowak et al.'s (2023) study (District 27J in Colorado) is one of the largest, most urban, and arguably least representative 4DSW districts across the U.S. Therefore, the relevance of these estimates for the average 4DSW district and the extent to which they hold true over time is unclear. The present study extends this developing body of research by examining the impact of 4DSWs on shortage rates, measured by the percentage of teachers in a school with a shortage credentials, and teacher attrition rates in Colorado.

1.5 Effects of 4DSWs on student attendance

Despite the strong perception among 4DSW communities that the schedule improves student attendance (Kilburn et al., 2021), several quasi-experimental studies have found either no impact or negligible effects of adopting the schedule on student attendance rates. 4DSW community members claim the schedule increases student attendance by allowing families to schedule appointments and activities or vacations that previously would have required a student to miss school for the fifth day (Kilburn et al., 2021). Such opportunities may be particularly consequential for school attendance in remote, rural areas where lengthy travel is often necessary for doctor's appointments and sports games.

However, empirical quasi-experimental research does not yet support these claims. The prior studies span several states and generally estimate small (around 0–1 percentage points) and statistically insignificant effects of 4DSWs on ADA rates (Anderson & Walker, 2015; Kilburn et al., 2021; Morton, 2023; Thompson, 2021b). Using high school data from Oregon, Thompson et al. (2021b) alternatively estimate significant, though still relatively small, negative impacts (1 to 2 percentage points) of the schedule on attendance rates, driven by larger negative impacts in non-rural schools.

As is also true for the present study, the discrepancy between the anecdotal claims and the existing research findings may be explained, in part, by the lack of sensitivity in the ADA measure. ADA does not typically capture instructional time that students miss for school-based extracurricular activities, such as athletics or Future Farmers of America (FFA) competitions, as an absence. Therefore, if students are missing less class time by not travelling to these events during the school day (and instead travelling on the day off), it may not be captured by districts' measures of ADA.

Another reason for the discrepancy could be because missing the same number of school days on a 4DSW relative to a five-day week (5DSW) schedule would be equivalent to missing a larger percentage of the total school year at a 4DSW school. Thus, community members may see that students are missing fewer total days, but they are missing an equivalent percentage of school time over the course of the year. Nevertheless, if the schedule is substantially reducing the portion of school that students miss for appointments or vacations, that should be captured by the ADA measure. We contribute to this developing body of research by examining the impact of 4DSWs on school-level ADA rates in Colorado.

1.6 4DSWs as a working conditions intervention

A secondary, broader contribution of this paper is the information it provides about the potential for working conditions to influence teacher recruitment and retention outcomes. While extensive research shows teachers' perceptions of their working conditions (e.g., testing and accountability pressures, administrative support, collegiality with other teachers) are strongly related to their job satisfaction and likelihood of leaving the profession, we know very little about how we can effectively intervene to improve these conditions (Borman & Dowling, 2008; Carver-Thomas & Darling-Hammond, 2017; Geiger & Pivovarova, 2018; Grissom, 2011; Ladd,

2011; Loeb & Luczak, 2013). This lack of evidence may stem from the scarcity of existing working condition interventions due to the perceived difficulty of changing subjective working condition factors shown to matter most for teacher retention—leadership, culture, and collegiality—through systemic policy. The 4DSW, however, is an example of a policy that primarily impacts teachers by changing the conditions of their jobs (i.e., their schedule and the total time they are expected to be at the school building, as opposed to their compensation) and is implemented by at least some districts with the express purpose of retaining and recruiting teachers (Heubeck, 2022). The evidence presented herein, therefore, also contributes some of the first evidence on the extent to which non-pecuniary working conditions policies can influence retention over time.

The impacts of the 4DSW on teacher recruitment and retention and student attendance outcomes are of central concern to policymakers and practitioners attempting to evaluate the tradeoffs of the adopting the schedule relative to policy alternatives (i.e., increased class sizes, increased shortage and turnover, other recruitment and retention strategies). 4DSWs have been shown to have small, negative average impacts on student achievement, and there is limited and conflicting evidence regarding the extent to which effects of the schedule on teacher recruitment and retention and student attendance are aligned with these effects. Positive effects on staffing and/or attendance would suggest that other aspects of the schedule are driving any negative impacts on student outcomes, whereas neutral or negative effects would support increased scrutiny of and/or restrictions around the use of the schedule, particularly in non-rural areas and schools with less instructional time, where it has the largest negative impacts on achievement (Morton et al., 2024; Thompson & Ward, 2022).

1.7 Research questions

In this study, we attempt to answer the following research questions:

1) What is the impact of the 4DSW on teacher shortages (as measured by the proportion of teachers employed with a shortage credential)?
2) What is the impact of the 4DSW on teacher retention, measured by:
    a) The percentage of teachers who move to other districts in Colorado?
    b) The percentage of teachers who leave public school teaching positions or the state?
3) What is the impact of the 4DSW on student attendance?

Do any of the above impacts of the 4DSW vary by school rurality?

2. Methods

2.1 Data

This study uses 14 years (2009-10 to 2022-23) of school-level data on school calendar waivers, 13 years (2010-11 to 2022-23) of school-level data on school and district demographics and student attendance, and 9 years (2013-14 to 2021-22) of anonymized staff-by-position level data from the Colorado Department of Education (CDE).[10] Additional school- and district-level demographic data are from the National Center on Education Statistics (NCES) Common Core of Data (CCD).

The data on school calendar waivers include information about each school's annual reduced calendar waiver status, allowing us to identify the year that the school first adopted the

[10] For the teacher recruitment and retention outcomes, our results are robust to excluding COVID-impacted school years 2019-20 and 2020-21 from the analysis. For the attendance outcomes, excluding these years meaningfully changes our estimated impact for large rural schools, as we describe in the results section herein. The full results are available upon request.

reduced calendar if they adopted between 2010-11 and 2022-23[11] and whether they ever switched back. Annual school demographics data from CDE include student enrollment counts, the percent of students eligible for free or reduced-price lunch (FRL), the percent of students who are English Language Learners (ELL), and the percent of students who receive special education services (SPED) through an Individualized Education Plan (IEP). District demographics from CDE also include whether a district is (1) small rural (i.e., located outside of a Census-defined urban area and enrolls fewer than 1,000 students), (2) large rural[12] (i.e., located outside of a Census-defined urban area and enrolls between 1,000 and 6,500 students), or (3) non-rural. The CCD provides annual data on the racial makeup of each school. The student attendance data include annual measures school-level total student-days attended and total student-days enrolled, which we use to calculate annual school-level ADA rates.

The annual staff-by-position data include the following information about each public school teacher hired in Colorado: race, gender, age, years of teaching experience,[13] highest level of education, grade(s) taught, subject area(s) focus (including SPED, ELL, and CTE), license type,[14] full time equivalency (FTE) and/or hours worked, and salary. For teachers who teach multiple grades and/or subjects, the data show the FTE and salary associated with each role.

[11] We make the assumption that schools that switch from not having a reduced calendar waiver to having a waiver during this period were not operating on a reduced calendar prior to 2009-10.
[12] Note that CDE uses the term "rural" to refer to districts located outside of a Census-defined urban area that enroll between 1,000 and 6,500 students. To distinguish these districts from "small rural" districts, we use the term "large rural" to describe CDE's "rural" districts.
[13] The data do not specifically include a measure of total years of teaching experience, but we create a proxy for this measure by calculating the total number of years elapsed since the earliest teaching start date recorded in our panel for each teacher, each calendar year.
[14] Per the recommendation of CDE and the publicly available information on CDE's website (https://www.cde.state.co.us/cdeprof/teacherreqs), we define the following license and authorization types as "shortage credentials:" Alternative Teacher License, Teacher of Record License, Interim Authorization – Teacher, Temporary Educator Eligibility Authorization, Adjunct Instructor Authorization, and Emergency Authorization. We consider the following license and authorization types to be "non-shortage credentials:" Professional Teacher Licenses, Initial Teacher License, Master Certificate – Teacher, Career at Technical Education Authorization, and Substitute Authorization.

2.2 Sample

The sample for the school-level analyses in this study includes the 2,095 public schools[15] across 179 districts and 6 BOCES that operated in Colorado during the study period from 2010-11 to 2022-23. Of these, 500 schools across 136 districts ever operate on a 4DSW, and we observe 265 of these schools adopt a 4DSW for the first time between 2010-11 and 2022-23. Table 1 shows the number of schools that operated on a 4DSW by school year and rurality, and the percentage of Colorado students enrolled in schools operating on a 4DSW. During the study period, the percentage of Colorado students enrolled in a school operating on a 4DSW increased from 2.8% to 12.4%, with the largest increase (from 6.2% to 9.7%) between the 2017-18 and 2018-19 school years. While small rural schools are more likely to operate on a 4DSW than large rural or non-rural schools, the number of non-rural schools operating on a 4DSW increased tenfold over the study period, from 8 schools in 2009 to 97 schools in 2022. Also of note, Colorado has a higher proportion of 4DSW districts that have some schools using a 4DSW and some schools using a 5DSW in the same year (26%) than the nation (8%; Thompson et al., 2021). These 35 "mixed" districts include a total of 205 schools that ever adopt a 4DSW and 806 schools that never adopt the schedule.

School- and district-level descriptive statistics for the school-level demographic and attendance data are presented in Table 2. Like 4DSW schools in other states (Morton et al., 2024), the Colorado schools that ever adopt a 4DSW are more likely to be located in rural areas and have smaller average enrollments, lower percentages of students classified as ELL, higher percentages of FRL-eligible students, and higher percentages of Native and White students than schools that never adopt a 4DSW. When comparing average daily attendance rates, Colorado

[15] Note that the Colorado School for the Deaf and Blind is excluded from the sample.

schools that ever adopt a 4DSW are similar to schools that never adopt a 4DSW (92.59% vs. 92.61%).

The teacher-level data include all 97,826 Colorado teachers employed in a Colorado public school from 2013-14 to 2021-22. Of these teachers, 16,792 are ever employed by a school that ever adopts a 4DSW. We aggregate these teacher data to the school-level and present school- and district-level teacher characteristics in Table 3. At schools and districts that ever adopt a 4DSW, teachers are demographically similar but are notably less likely to be female (74.6% vs. 78.2%). All other school-level teacher descriptives presented herein weight teachers by their FTE.[16] We find that schools that ever adopt a 4DSW have a substantially lower average teacher salary than schools that do not adopt a 4DSW ($42,013 vs. $56,112 in 2023 dollars), and their teachers are more likely to leave the district each year (17.2% vs. 15.2%), specifically by moving to another district in the state (6.5% vs. 4.6%). Alternatively, rates of teachers exiting the teaching workforce and/or state are similar (11.1% vs. 11.2%). We also show that schools that adopt 4DSWs have a higher percentage of teachers with shortage credentials (3.6% vs. 2.3%), a slightly higher percentage of teachers who are eligible for retirement with 30 or more years of experience (2.1% vs. 1.0%), and a notably smaller percentage of teachers who hold an advanced degree (40.3% vs. 54.5%).

For the purposes of our analysis, we restrict each data panel to the schools we observe in each year of the panel we use for each analysis. In accordance with the differences-in-differences approach (Callaway & Sant'Anna, 2021) we use herein and describe in additional detail below, we also exclude schools that have a 4DSW in the first year of each panel (e.g., "always treated"

[16] We find some positions are allocated an implausibly high FTE. In consultation with CDE, we deal with this by excluding all individual position-year observations with FTE > 1.3 (which accounts for 0.6% of position-level observations) and excluding all staff with total FTE per year exceeding 1.3 (which accounts for 0.6% of staff across years). Nevertheless, we find our results are robust to including these observations (results available upon request).

units), as these schools' outcomes are not a reasonable counterfactual for schools that adopt a 4DSW when estimating the effect of adopting a 4DSW relative to staying on a 5DSW. We also conduct these analyses using an intent-to-treat (ITT) approach that estimates the effect of adopting the 4DSW over time for all schools that ever adopt a 4DSW, regardless of if they switch back to a 5DSW.[17] Relative to a treatment-on-the-treated (TOT) analysis that excludes schools that adopt a 4DSW schedule and switch back during the study period, the ITT analysis provides a more conservative, attenuated estimate of the average treatment effect. Therefore, we present the ITT results herein, but we note the two approaches yield substantively similar results.

For the analyses of teacher outcomes, these restrictions result in an analytic sample of 1,428 schools of which 128 are treated during the study period for RQ1 and 1,420 schools of which 182 are treated for RQ2. For the attendance analysis (RQ3), the analytic sample includes 1,373 schools, of which 242 are treated during the study period. Because we exclude schools that have 4DSWs in the first year of each panel, the analytic samples necessarily underrepresent 4DSW schools that adopted the schedule in earlier years, prior to the start of the data. As displayed in Appendix Tables A1 and A2, schools in small rural districts that adopt 4DSWs are underrepresented in the analytic samples relative to these schools across the state, whereas non-rural 4DSW schools are overrepresented. It follows that the schools that adopt 4DSWs in the analytic samples tend to have larger school and district enrollments, a higher share of Hispanic students, a lower share of White students, more teachers, slightly lower teacher turnover rates, higher teacher salaries, and a smaller share of teachers employed with shortage credentials than

[17] We cannot say for certain that schools that do not apply for the reduced calendar waiver to operate fewer than 160 days in a given year after applying for the waiver in previous years are switching back to a five-day school week. It is possible these schools are operating for 160 days or more and are consistently using a 4DSW, but such a practice would necessitate a substantially longer school year (or substantially reduced breaks throughout the year) and would be an anomaly relative to existing implementations of the 4DSW (Thompson et al., 2021). Therefore, we generally assume schools that do not have a waiver in a given year after having one in a prior year have "switched back" to a five-day week.

schools that adopt 4DSWs across the state. The sets of schools that never adopt a 4DSW in the analytic samples have higher school enrollments, more teachers per school, lower teacher turnover rates, and a smaller share of teachers employed with a shortage credential than these schools across the state. These differences suggest the analytic samples are not representative of all schools that do and do not adopt 4DSWs in Colorado, and it is likely that our average results will underrepresent the effects of 4DSWs at schools in small rural districts.

2.3 Empirical strategy

To examine the effect of 4DSWs on teacher recruitment (RQ1), teacher retention (RQ2), and student attendance (RQ3), we use a synthetic control difference-in-differences (DiD) quasi-experimental research design. The broader DiD approach leverages panel data to estimate the impact of the 4DSW policy by comparing changes over time in outcomes of schools that adopt 4DSWs to the contemporaneous changes in schools that do not have 4DSWs during our study period. To use the DiD method without synthetic control, it is necessary that "control" schools (i.e., 5DSW schools that never adopt a 4DSW) are trending similarly to "treatment schools" (i.e., schools that adopt a 4DSW) on key outcomes and covariates during the *pre-treatment period*. Similar to Camp's (2024) study of 4DSWs in Arkansas, we find that Colorado schools that eventually adopt 4DSWs are trending differently on some key outcomes than 5DSW schools during the pre-treatment period, suggesting that unobserved factors[18] influence whether or not a school adopts a 4DSW. In other words, we find evidence that the parallel trends assumption necessary for DiD analysis is violated during the pre-treatment period, making it impossible to know if any treatment effects (or lack thereof) estimated using the canonical DiD method are

[18] Among the many unobserved factors in these data that could drive selection into 4DSWs, we speculate that some of these factors could include: superintendents' prior exposure to or experience with 4DSWs, distance from other schools that adopt 4DSWs, community perceptions of or experience with the 4DSW, the availability of childcare (whether provided by the family or an external party) on the fifth day, and families' work schedules.

representing causal effects of the 4DSW, as opposed to pre-existing differences between the two groups that would have resulted in these differences in the post-treatment period, regardless of adopting a 4DSW (or not).

Given the above findings, we use the synthetic control method (Arkhangelsky et al., 2021) to construct an "artificial" control group that uses a weighted combination of demographic and outcome data from control schools to closely match the characteristics and trends of each cohort of schools that adopt 4DSWs (i.e., schools that adopted the 4DSW in 2014, schools that adopted the 4DSW in 2015, etc.) before they adopt the schedule.

The central assumption of the analytic approach is that the outcomes of the synthetic control group represent what would have happened in the schools that adopt 4DSWs during the post-treatment period if they had never adopted the schedule. Therefore, by comparing the outcomes of the schools that adopt 4DSWs to the outcomes of the synthetic control group in the post-treatment period, we can estimate the causal effect of 4DSWs. This approach also advantageously allows us to control for time-variant school characteristics that may be influencing outcomes over time, including school and district student enrollment, the percent of students who qualify for free-or-reduced price lunch (FRPL), the percent of students who have an Individualized Education Program (IEP), and the percent of students who are English Language Learners (ELL). To address to concerns about the implications of variation in treatment timing when using DiD specifications (Goodman-Bacon, 2021; de Chaisemartin & D'Haultfoeuille, 2020; Callaway & SantAnna, 2021; Roth et al., 2023; Sun & Abraham, 2021), we estimate separate effects for each treatment cohort and calculate an aggregate effect that weights these estimates by the share of treated schools in the cohort.

Teacher Recruitment and Retention

To estimate the effect of 4DSWs on teacher recruitment (RQ1) and retention (RQ2), we examine the impact of adopting the schedule on a school's percentage of teachers employed with a shortage credential (a proxy for shortages; RQ1), who move to another district in Colorado (RQ2a), and who exit public school teaching positions or state (RQ2b). Each of these variables is weighted by teacher FTE. Using the synthetic control district as the comparison group, we use the following DiD specification to estimate the effect of adopting a 4DSW on these outcomes separately for each treatment cohort:

$$Y_{sd,t+1} = \alpha_s + \gamma_t + \beta Fourday_{sd,t+1} + \delta \boldsymbol{R}_{sdt} + \varepsilon_{sdt}$$

where $Y_{sd,t+1}$ represents the outcome in school *s* and district *d* in year *t*+1. α_s represents school fixed effects and γ_t represents year fixed effects. $Fourday_{csd,t+1}$ is a school-level indicator of 4DSW status in year *t*+1. The β coefficient is the primary coefficient of interest, representing the effect, expressed in percentage points, of a school adopting a 4DSW in year *t*+1 on the relevant outcome. $\mathbf{R}_{\mathrm{sdt}}$ is a vector of time-variant control variables (i.e., natural log of school enrollment, natural log of district enrollment, percent FRPL-eligible, percent with an IEP, and percent ELL) for school *s* and district *d* in year *t*. ε_{sdt} is an idiosyncratic error term that accounts for clustering at the school level.

Student Attendance

We use a very similar approach to estimate effects of 4DSWs on student attendance (RQ3), measured as the school-level ADA rate. For this specification, however, we estimate the impact of 4DSWs in year *t* (as opposed to year *t*+1) on ADA rates in year *t*, controlling for covariates from the same year (as opposed to from the prior year):

$$Y_{sdt} = \alpha_s + \gamma_t + \beta Fourday_{st} + \delta \boldsymbol{R}_{sdt} + \varepsilon_{sdt}$$

where Y_{sdt} represents the ADA rate for school *s* in district *d* and year *t*.

Heterogeneous Effects

Following Morton et al. (2024) and Thompson et al. (2022), we examine whether the effects of 4DSWs vary by district rurality. To do so, we reestimate each of our primary specifications three times, limiting the sample to CDE's defined (1) small rural districts with fewer than 1,000 enrolled students, (2) large rural districts with 1,000 to 6,500 students, and (3) non-rural districts. The β coefficients in these models can be respectively interpreted as the impact of a school adopting a 4DSW in a small rural, large rural, or non-rural district relative to not adopting a 4DSW in that type of district.

3. Results

In this section, we present the results for each of the examined outcomes, describing the overall effects (RQs 1-3) and any heterogeneous effects by rurality (RQ4) for each outcome in turn. Table 4 displays the results of the synthetic control DiD analyses for each of the four primary outcomes (in rows), separately for all schools, small rural schools, large rural schools, and nonrural schools (in columns).

3.1 Teacher recruitment

We find the 4DSW increases a school's percentage of FTE with a shortage credential by a statistically significant 0.11 percentage points on average (see Table 4). This finding is largely driven by increases in non-rural schools, where 4DSWs increase FTEs with shortage credentials by 0.25 percentage points (p<.01). Based on the average percentage of FTE with shortage credentials at non-rural schools that go on to adopt a 4DSW in the analytic sample (4.39%), the 0.25 percentage point increase is equivalent to a 6% increase, or an additional 0.07 FTE per school. The average effect of the 4DSW on shortage credentials in small rural schools, alternatively, is negative and not significant. Disaggregated results for each treatment cohort and

the share of treated schools in each cohort are presented in Appendix Table A3 and Appendix Figure A1. These results do not show any consistent pattern in the effects of 4DSWs for earlier versus later cohorts of adopters.

3.2 Teacher retention

For both teacher retention outcomes and across all rurality subgroups, we fail to detect statistically significant effects of the 4DSW (see Table 4). The 95% confidence interval of the average impact of the 4DSW on the percentage of FTE who move districts in Colorado (β=-0.86 percentage points, p>.05) suggests we can rule out effects larger than a 0.42 percentage point increase or a 2.14 percentage point decrease. Before adopting the 4DSW, these schools had about 7.15% of their teachers move to other districts on average, such that the upper and lower bounds of the 95% confidence interval respectively translate to a 6% increase and a 30% decrease in the percentage of FTE moving to another district. Similarly, for the percentage of FTE who leave public school teaching or the state, we can rule out impacts of the 4DSW larger than a 0.84 percentage point increase or a 1.37 percentage point decrease, which respectively translate to a 9 percent increase and a 15 percent decrease, based on a baseline exit rate of 8.98% in schools that go on to adopt 4DSWs. It is worth noting the estimated impacts are consistently larger and more favorable among small rural schools (percent move β=-2.66 percentage points, a 32% decrease relative to baseline; percent exit β=-1.90 percentage points, a 21% decrease relative to baseline), but they still are not statistically significant. Disaggregated results for each treatment cohort and the share of treated schools in each cohort are presented respectively for the two outcomes in Appendix Tables A4 and A5 and respectively displayed in Appendix Figures A2 and A3. These results also do not show any consistent pattern in the effects of 4DSWs for earlier versus later cohorts of adopters.

3.3 Student attendance

Across all schools, we also do not detect a significant effect of 4DSWs on student attendance (β=0.25 percentage points, p>.05; see Table 4). The 95% confidence interval suggests we can rule out an effect larger than a 0.14 percentage point decrease or 0.64 percentage point increase in daily attendance rates for the average 4DSW over time. We also fail to detect significant effects of 4DSWs on attendance when restricting the sample to small rural or non-rural schools, but we estimate a significant 0.76 percentage point decrease in ADA. This effect is within the range of typical within-school year-over-year fluctuations (i.e., increases or decreases) in ADA, which are about 2.41 percentage points across all Colorado schools and about 1.66 percentage points in large rural schools that go on to adopt 4DSWs. Therefore, we interpret the 0.76 percentage point decrease as a meaningfully small impact on ADA, equivalent to about 46% of the normal annual change in ADA among non-rural schools that adopt 4DSWs. We also note that when excluding the COVID-impacted school years (2020-21 and 2021-22) from the analysis, when ADA may have been measured differently to account for remote schooling, we no longer detect a significant effect of 4DSWs on ADA in large rural schools (β=0.26 percentage points, p>.05). Thus, the negative effect of 4DSWs on large rural schools is disproportionately concentrated in the COVID-impacted school years. Disaggregating the results by treatment cohort, we see some variation in effects between cohorts but do not detect any meaningful patterns in these differences (see Appendix Table A6 and Appendix Figure A4).

4. Discussion

Overall, we do not find evidence that supports the claims that adopting a 4DSW improves teacher recruitment or retention outcomes. Rather, using a synthetic control difference-in-differences approach, we generally estimate meaningfully small and/or statistically insignificant effects of the schedule on these outcomes. Among non-rural schools, adopting a 4DSW

significantly increases the percentage of FTE with shortage credentials by about 6%. If all 97 non-rural Colorado schools that had a 4DSW in 2022-23 experienced this impact, we estimate the 4DSW accounts for approximately 6 to 7 of these schools' 131.5 total FTE[19] that have a shortage credential instead of a traditional license across these schools. While not entirely trivial, these additional shortages comprise a very small percentage of the workforce in these schools. Much more noteworthy is the lack of results showing that 4DSWs have significantly reduced teacher shortages over time, including in more recent cohorts of adopters, despite of district leaders' increasing use of the schedule as both a recruitment and retention strategy (Heubeck, 2022).

We also generally do not find evidence supporting the claim that 4DSWs are improving teacher retention in Colorado. Specifically, we estimate statistically insignificant effects of adopting the schedule on the percentage of FTE who move districts in Colorado and who leave teaching or the state. We find larger and more advantageous effects for small rural schools than other schools, but these effects are also statistically insignificant. Our null effects on the percentage of FTE who move districts contrasts Camp's (2024) finding that the rate of teacher moves to other districts significantly decreased by 1.4 percentage points in Arkansas. State policies and varying rationales and timing for adopting 4DSWs across states may interact with the 4DSW such that there are different impacts of adopting the schedule on teacher retention across states. Nevertheless, the 95% confidence interval of our estimate of the effect of 4DSWs on the percent of teachers who move to another district includes a 1.4 percentage point decrease, such that we cannot rule out similar effects in Colorado and Arkansas. Moreover, in agreement

[19] We calculate the 4DSW's impact on total FTE with shortage credentials instead of traditional licenses at non-rural 4DSW schools using the following formula: shortage credential FTE increase = 0.0025 * average non-rural school pre-treatment FTE * 97 non-rural 4DSW schools.

with our findings, Camp (2024) does not detect a significant effect of 4DSWs on the percentage of teachers who leave teaching or the state. Perhaps unsurprisingly, our findings contrast those of Nowak et al. (2023), who analyze the impacts of the schedule on retention in a single, nonrepresentative non-rural 4DSW district in Colorado and find a 5 percentage point decrease in retention. We check if it could be the case that positive effects on retention and recruitment are seen primarily among later cohorts of 4DSW adopters in Colorado, those most likely to cite teacher recruitment and retention as their primary motivation for adopting the schedule. But we do not find that these schools are consistently seeing more advantageous effects on these outcomes than earlier adopters.

Finally, consistent with previous research on 4DSW impacts on attendance in other states, we do not detect an effect of 4DSWs on student attendance rates on average. However, we do find a significant 0.76 percentage point decrease in attendance rates specifically for large rural schools that adopt 4DSWs (equivalent to about 46% of the normal annual fluctuations in ADA in these schools). We also find the effect is driven by disproportionate decreases in ADA in 4DSW schools during the COVID-impacted school years. Regardless, the negative impact is meaningfully small, much less than the ~2 percentage point declines in attendance U.S. schools have seen in the wake of the pandemic (Carminucci et al., 2021; Fuller et al., 2023). Moreover, the null and negative findings contrast the anecdotal claims of 4DSW communities that attendance increases on the 4DSW (Kilburn et al., 2021). Across all Colorado schools during the present study's time period, ADA rates consistently fall between 90-95% and have generally decreased slowly over time, such that policies that drive additional decreases in attendance are cause for concern. It will be important for future research to investigate the extent to which these

average impacts on daily attendance vary across student groups and whether 4DSWs are driving higher rates of chronic absenteeism.

4.1 Limitations

This study faces several limitations related to the restrictions we had to make to the analytic samples and the measures we have for teacher shortages and student attendance. First, the schools that adopt 4DSWs in our analytic samples vary in meaningful ways from the broader population of 4DSW schools in Colorado. Our analytic samples underrepresent small rural 4DSW schools and overrepresent non-rural 4DSW schools. Our analytic samples also overrepresent schools that adopted 4DSWs in more recent years, since 2014-15 for the teacher outcomes and since 2010-11 for the attendance outcomes, though we know that a substantial share (36%) of the schools that have 4DSWs in Colorado adopted them before the 2010-11 school year. Relatedly, our impact estimates represent the average effect of having a 4DSW for 4-5 years for the teacher outcome samples and 6-7 years for the attendance outcome sample. It is possible that, particularly for staffing outcomes, it could take more time to see benefits. For instance, it could be that retention only improves (or decreases) after schools hire different teachers, such that the impact builds over time.

Our measures of teacher shortages and student attendance are also limited in their ability to fully capture the underlying phenomena we are trying to measure. More specifically, we use the percentage of teachers employed with shortage credentials as a proxy for shortage rates, but we do not observe vacancies or other recruitment outcomes directly. Indeed, it is possible that 4DSWs increase the share of teachers employed with shortage credentials while reducing overall vacancies if they are just filling more vacancies with these less qualified teachers. In that case, 4DSWs may still be considered an effective recruitment tool for decreasing vacancies, but we

cannot observe the extent to which that is happening. The student attendance measure, ADA, faces similar limitations to that of the previous studies that have used this measure. If 4DSWs increase attendance rates solely by reducing the amount of class time students miss for athletics or other similar absences that are not recorded in the ADA measure, we would not be able to observe that effect. However, reductions in excused and unexcused absences (e.g., for appointments, illness, vacations) should be observed in the ADA measure. Future research could build on the findings herein by leveraging more precise measures of teacher shortages and student attendance.

4.2 Policy implications

The results in this study do not provide support for the claim that adopting a 4DSW is an effective way to reduce teacher shortages or to increase teacher retention by way of improving teacher working conditions. These findings stands in stark contrast to the growing rationale for adopting the schedule across the U.S. One possible explanation for this discrepancy could be that district leaders may reasonably perceive their teachers as likely to leave their district if they do not adopt a 4DSW based on their teachers' expressed intentions, but most these teachers would ultimately not make different decisions about their employment if the district did not adopt the 4DSW. In support of this theory, Nguyen et al. (2024) find that teachers' self-reported intentions to quit teaching are related to, but distinct from, actual turnover rates. Indeed, *most* teachers who indicate that they plan to leave their school do not end up leaving (~60%), and many teachers who do not indicate that they intend to leave do end up leaving (~14%). While we can only speculate about the mechanism underlying the lack of the 4DSW's effects on retention herein, this study shows that it is not the case that Colorado schools that adopted the 4DSW would have seen much greater teacher attrition if they had not adopted the 4DSW.

Overall, our findings add to the growing body of empirical evidence that 4DSWs generally have null or negative impacts on schools and students, and that they do not, on average, result in the improvements districts and schools hope to see when they adopt them. Proponents claim that the schedule decreases teacher shortages, improves teacher retention, increases student attendance, and saves money while not impacting student achievement; in contrast, causal research studies find no or minimal positive impacts of the schedule on these outcomes and negative average effects on student achievement (e.g., Kilburn et al., 2021; Morton, 2021; Morton et al., 2024; Thompson & Ward, 2022). A couple studies find benefits of the schedule related to decreasing disciplinary incidents (Morton, 2023) and increasing students' total sleep (Kilburn et al., 2023), but these are not common motivations for adopting or continuing to use the schedule. Nevertheless, community approval ratings of the schedule are remarkably high (Kilburn et al., 2023) and adoption of the schedule continues to grow (Thompson, 2023, as cited in Cook, 2023). Future research should explore this disconnect between communities' positive perceptions of the schedule and the mostly negative or null impacts of 4DSWs to date on student and teacher outcomes. In the absence of additional positive findings, school districts using or considering adopting the 4DSW should proceed with caution.

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Tables and Figures

Table 1. Reduced calendar waivers by year

School year (spring)	Schools without a reduced calendar waiver					Schools with a reduced calendar waiver				
	Total schools	Non-rural schools	Large rural schools	Small rural schools	% CO K-12 students	Total schools	Non-rural schools	Large rural schools	Small rural schools	% CO K-12 students
2010	1567	1180	228	158	97.17%	180	8	21	151	2.83%
2011	1496	1136	218	142	94.42%	215	29	24	162	4.06%
2012	1499	1157	211	131	94.85%	223	29	27	167	4.24%
2013	1503	1180	192	131	94.15%	239	28	42	169	4.89%
2014	1513	1193	194	126	94.19%	236	28	42	166	4.85%
2015	1535	1207	212	115	94.51%	230	31	37	162	4.94%
2016	1525	1205	204	115	93.61%	227	31	41	155	4.97%
2017	1553	1232	206	111	94.16%	235	32	49	154	5.23%
2018	1540	1250	198	90	93.33%	265	32	62	171	6.16%
2019	1487	1224	177	84	89.44%	335	89	71	175	9.71%
2020	1486	1231	186	65	89.21%	344	88	72	184	10.17%
2021	1489	1228	198	59	89.35%	350	89	64	197	10.33%
2022	1480	1210	207	58	88.31%	356	88	72	196	10.89%
2023	1429	1198	181	43	86.94%	407	97	84	226	12.42%

Note. Data are from the Colorado Department of Education from 2009-10 to 2022-23. Instructional days data were not available for the 2010-11, 2011-12, or 2014-15 school years.

Table 2. School-level demographics and characteristics by ever 4DSW status

	All schools in CO	Never 4DSW	Ever 4DSW
Total schools	2,095	1,595	500
School by year observations	23,616	17,829	5,787
School characteristics			
Average student enrollment	469.81	537.95	259.88
% Asian	2.42%	2.91%	0.72%
% Black	4.22%	5.04%	1.45%
% Hispanic	33.76%	33.61%	34.23%
% Native	0.93%	0.71%	1.62%
% White	55.28%	53.61%	60.38%
% FRL	45.55%	43.13%	52.97%
% IEP	11.07%	10.95%	11.46%
% ELL	14.23%	15.98%	8.84%
Student-teacher ratio	19.95	20.30	17.98
% in non-rural district	70.59%	86.16%	22.64%
% in large rural district	14.10%	10.86%	24.09%
% in small rural district	15.12%	2.73%	53.27%
Average district enrollment	30,677.55	39,020.64	4,973.57
School-level average daily attendance (ADA) rate	92.61%	92.62%	92.59%
Total districts	185	49	136
Schools per district	12.47	21.01	7.92

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2010-11 to 2022-23. Small rural districts are located outside of a Census-defined urban area and enroll fewer than 1,000 students, large rural districts are located outside of a Census-defined urban area and enroll between 1,000 and 6,500 students, and non-rural districts include all other districts.

Table 3. School- and district-level teacher characteristics by ever 4DSW status

	All schools in CO (N=2,000)	Never 4DSW (N=1,518)	Ever 4DSW (N=482)
School-level teacher counts and demographics			
FTE per year	28.01	31.43	17.22
Teachers per year	30.34	33.95	18.95
% Asian	1.02%	1.17%	0.55%
% Black	1.32%	1.58%	0.51%
% Hispanic	7.96%	7.76%	8.58%
% White	88.01%	87.69%	89.00%
% Female	77.32%	78.18%	74.63%
Age	41.63	41.32	42.64
School-level employment characteristics (weighted by FTE)			
% Leave district per year	16.51%	16.05%	17.96%
% Move districts in CO	5.36%	4.93%	6.72%
% Leave teaching or state	11.15%	11.12%	11.24%
% New hires per year	15.33%	15.22%	15.65%
Average teacher salary	52,715	56,112	42,013
School-level teacher qualifications (weighted by FTE)			
% Shortage credential	2.72%	2.41%	3.70%
Average years of experience	7.62	7.60	7.69
% <3 years	26.82%	26.77%	26.99%
% 3-9 years	36.65%	33.96%	35.67%
% 10-29 years	34.89%	34.91%	34.83%
% ≥30 years	1.23%	0.96%	2.08%
Highest degree completed			
% Less than BA	0.63%	0.50%	1.03%
% BA	47.61%	44.36%	57.84%
% Adv. degree (MA +)	51.05%	54.46%	40.31%
District-level teaching subject area (weighted by FTE)			
STEM	19.30%	19.04%	19.39%
Special education	8.23%	9.07%	7.92%
CTE	0.68%	0.57%	0.71%
ELL	0.55%	0.95%	0.41%
Elementary	37.69%	34.78%	38.74%
District-level teacher grade level (weighted by FTE)			
K-5	47.52%	44.59%	48.58%
6-8	28.40%	23.68%	30.11%
9-12	22.79%	30.77%	19.89%

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22. Years of experience is measured as the number of years elapsed since the teacher's first year teaching in CO. Shortage credentials include alternative and emergency teacher licenses. A district is considered "Ever 4DSW" if they ever have one school with 4DSW.

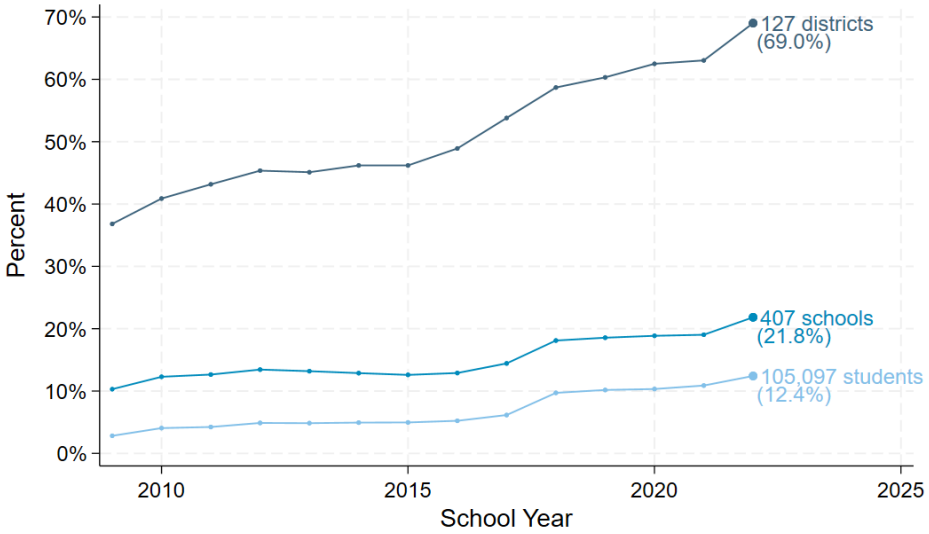
Table 4. Synthetic Difference-in-Differences Estimates of 4DSW Effects on Treated Schools by Rurality

Outcome		All schools (1)	Schools in small rural districts (2)	Schools in large rural districts (3)	Schools in non-rural districts (4)
RQ1: Shortage credential percent	4DSW next year	0.109*	-0.042	0.063	0.251**
		(0.051)	(0.116)	(0.097)	(0.092)
	Schools	1428	90	152	1121
	Treated schools	182	64	50	61
	Observations	12852	810	1368	10089
RQ2a: Percent move	4DSW next year	-0.857	-2.659	0.942	0.765
		(0.653)	(2.144)	(0.847)	(0.617)
	Schools	1420	89	150	1117
	Treated schools	182	64	50	61
	Observations	12780	801	1350	10053
RQ2b: Percent exit	4DSW next year	0.263	-1.901	0.367	-0.329
		(0.564)	(2.484)	(0.946)	(0.592)
	Schools	1420	89	150	1117
	Treated schools	182	64	50	61
	Observations	12780	801	1350	10053
RQ3: Average daily attendance (ADA)	4DSW same year	0.248	-0.238	-0.758*	0.381
		(0.199)	(0.572)	(0.372)	(0.341)
	Schools	1373	100	159	1040
	Treated schools	242	77	67	78
	Observations	17849	1300	2067	13520

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

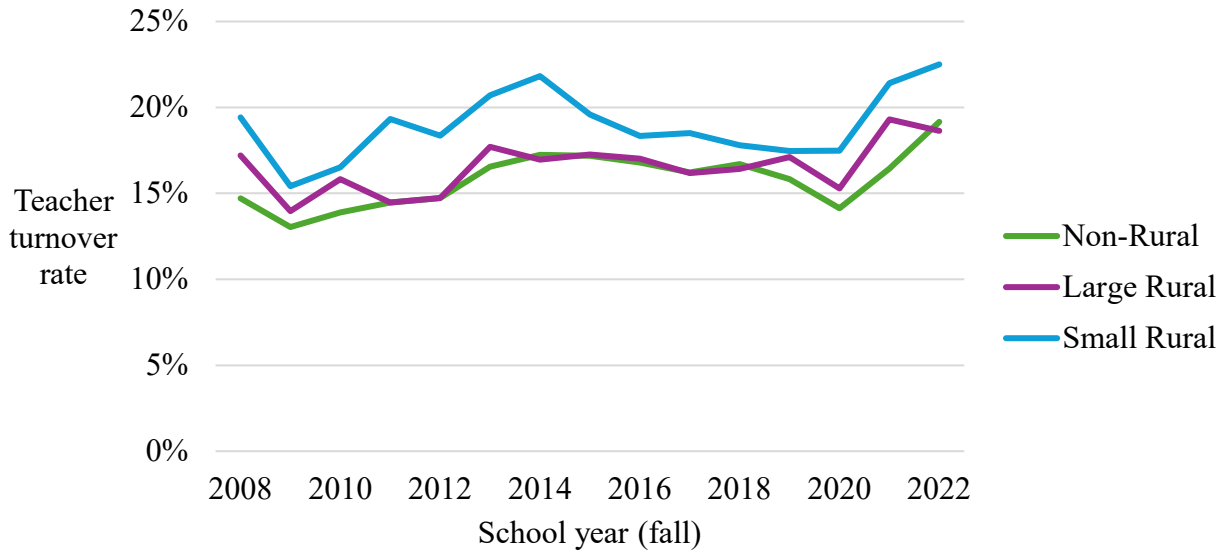
Note. Standard errors for each point estimate are shown below the estimate in parentheses. All teacher outcomes (i.e., shortage credential percent, percent move, percent exit) are weighted by FTE. All data are from the Colorado Department of Education (CDE) and the Common Core of Data. The school attendance and demographic datasets span 2010-11 to 2022-23, and the staffing data span 2013-14 to 2021-22. Small rural districts are located outside of a Census-defined urban area and enroll fewer than 1,000 students, large rural districts are located outside of a Census-defined urban area and enroll between 1,000 and 6,500 students, and non-rural districts include all other districts.

Figure 1. Reduced Academic Calendar Adoption by Year, 2008 to 2022



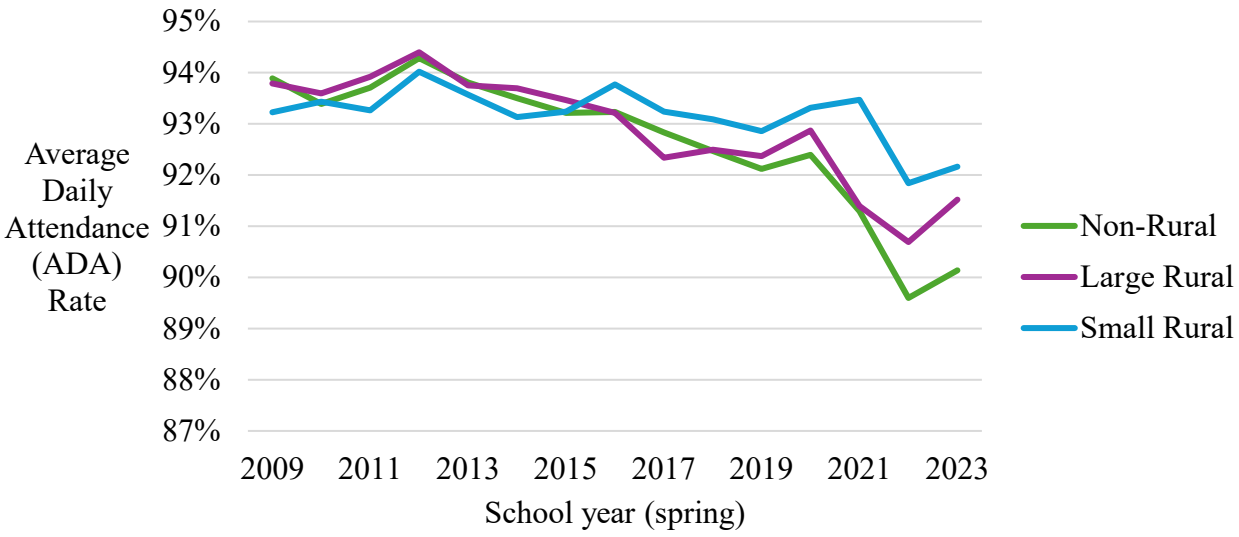
Note. Data are from the Colorado Department of Education from 2009-10 to 2022-23.

Figure 2. District-Level Teacher Turnover Rate in Colorado by Rurality, 2008 to 2022



Note. Annual district-level teacher turnover data are made publicly available by the Colorado Department of Education at https://www.cde.state.co.us/cdereval/staffcurrent. The turnover rate in a given year represents the percentage of teachers who were teaching in the district the previous year and are no longer teachers in the same district in the given year. Small rural districts are located in rural areas and serve fewer than 1,000 students, large rural districts are located in rural areas and serve between 1,000 and 6,500 students, and non-rural districts are located in non-rural areas.

Figure 3. School-Level Average Daily Attendance Rate in Colorado by Rurality, 2008 to 2022



Note. Annual attendance data are from the Colorado Department of Education. Small rural districts are located in rural areas and serve fewer than 1,000 students, large rural districts are located in rural areas and serve between 1,000 and 6,500 students, and non-rural districts are located in non-rural areas.

Appendix

Appendix Table A1. School-level demographics and characteristics by ever 4DSW status and analytic sample

	Sample							
	All CO		RQ1		RQ2		RQ3	
Ever waiver school	No	Yes	No	Yes	No	Yes	No	Yes
Total schools	1,595	500	1,246	182	1,238	182	1,131	242
School by year observations	17,829	5,787	11,214	1,638	11,142	1,638	14,703	3,146
School characteristics								
Average student enrollment	537.95	259.88	561.86	360.27	564.89	360.27	570.17	344.65
% Asian	2.91%	0.72%	2.99%	1.03%	3.01%	1.03%	3.02%	0.80%
% Black	5.04%	1.45%	4.84%	1.92%	4.81%	1.92%	4.48%	1.62%
% Hispanic	33.61%	34.23%	33.29%	43.72%	33.28%	43.72%	32.08%	40.84%
% Native	0.71%	1.62%	0.69%	1.44%	0.69%	1.44%	0.69%	1.23%
% White	53.61%	60.38%	53.92%	50.40%	53.93%	50.40%	55.50%	53.65%
% FRL	43.13%	52.97%	42.61%	55.95%	42.64%	55.95%	42.08%	54.44%
% IEP	10.95%	11.46%	11.12%	11.62%	11.11%	11.62%	11.03%	11.61%
% ELL	15.98%	8.84%	15.71%	12.84%	15.78%	12.84%	15.21%	10.96%
Student-teacher ratio	20.30	17.98	15.86	14.95	15.86	14.95	20.62	19.27
% Non-rural district	86.16%	22.64%	86.73%	33.52%	86.97%	33.52%	86.81%	32.23%
% Rural (not small) district	10.86%	24.09%	10.46%	28.63%	10.34%	28.63%	10.43%	32.39%
% Small rural district	2.73%	53.27%	2.73%	37.85%	2.61%	37.85%	2.77%	35.38%
Average district enrollment	39,021	4,938	39,734	7,360	39,866	7,360	38,251	6,653
School-level ADA rate	92.62%	92.59%	92.52%	92.30%	92.56%	92.30%	92.88%	92.43%
Total districts	84	136	65	46	65	46	62	64
Schools per district	21.01	7.92	20.08	10.62	19.95	10.56	19.21	8.19

Note. ADA = Average Daily Attendance. Data are from the Colorado Department of Education and the Common Core of Data from 2010-11 to 2022-23. Because some districts have both schools that adopt 4DSWs and those that do not, some districts are counted both in the "No" and "Yes" ever waiver school columns for each sample.

Appendix Table A2. School- and district-level teacher characteristics by ever 4DSW status and analytic sample

	Sample							
	All CO		RQ1		RQ2		RQ3	
Ever waiver district	No	Yes	No	Yes	No	Yes	No	Yes
School-level teacher counts and demographics								
FTE per year	24.16	13.29	32.85	22.56	33.04	22.56	25.65	16.67
Teachers per year	26.10	14.61	35.42	24.10	35.61	24.10	27.65	17.88
% Asian	1.17%	0.55%	1.14%	0.67%	1.14%	0.67%	1.05%	0.59%
% Black	1.58%	0.51%	1.45%	0.57%	1.45%	0.57%	1.31%	0.56%
% Hispanic	7.76%	8.59%	7.63%	10.42%	7.65%	10.42%	7.47%	9.92%
% White	87.69%	89.00%	88.06%	87.14%	88.05%	87.14%	88.50%	87.66%
% Female	78.18%	74.63%	78.29%	74.57%	78.36%	74.57%	78.59%	74.14%
Age	41.32	42.64	41.51	41.71	41.51	41.71	41.79	42.00
School-level employment characteristics (weighted by FTE)								
% Leave district per year	15.22%	17.20%	14.20%	16.20%	14.18%	16.02%	13.75%	15.56%
% Move districts in CO	4.63%	6.49%	4.25%	6.23%	4.25%	6.23%	4.14%	5.67%
% Leave teaching or state	10.59%	10.71%	9.94%	9.79%	9.93%	9.79%	9.61%	9.89%
% New hires per year	14.43%	15.02%	12.80%	14.14%	12.78%	14.14%	12.11%	13.60%
Avg. teacher salary	$56,112	$42,013	$57,196	$46,722	$57,238	$46,722	$58,079	$46,553
School-level teacher qualifications (weighted by FTE)								
% Shortage credential	2.25%	3.57%	2.08%	3.32%	2.08%	3.32%	1.91%	3.17%
Avg. years of experience	7.60	7.69	7.92	7.89	7.94	7.89	8.24	8.17
% <3 years	26.77%	26.99%	24.96%	26.68%	24.95%	26.68%	23.35%	25.22%
% 3-9 years	33.96%	35.67%	36.90%	35.96%	36.90%	35.96%	36.42%	35.77%
% 10-29 years	34.91%	34.83%	36.71%	34.54%	36.73%	34.54%	38.75%	36.34%
% ≥30 years	0.96%	2.08%	1.02%	2.01%	1.03%	2.01%	1.09%	2.06%
Highest degree completed								
% Less than BA	0.50%	1.03%	0.43%	0.87%	0.44%	0.87%	0.42%	0.93%
% BA	44.36%	57.84%	43.76%	57.88%	43.66%	57.88%	43.06%	56.57%
% Adv. degree (MA +)	54.46%	40.31%	55.23%	40.92%	55.33%	40.92%	55.97%	42.01%
District-level teaching subject area (weighted by FTE)								
STEM	17.96%	18.23%	18.38%	17.19%	18.29%	17.19%	18.29%	19.12%
Special education	8.88%	7.36%	8.91%	7.37%	8.93%	7.38%	9.08%	7.56%
CTE	0.49%	0.65%	0.47%	0.46%	0.47%	0.46%	0.50%	0.82%
ELL	1.09%	0.42%	0.99%	0.70%	1.00%	0.70%	1.12%	0.62%
Elementary	35.17%	38.72%	33.94%	39.87%	33.96%	39.88%	34.34%	35.70%
District-level teacher grade level (weighted by FTE)								
K-5	45.14%	48.53%	43.63%	50.03%	43.64%	50.04%	44.15%	44.59%
6-8	23.46%	30.26%	22.94%	25.70%	22.95%	25.70%	24.60%	29.86%
9-12	30.40%	19.83%	32.51%	23.35%	32.48%	23.34%	30.27%	24.52%

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22. A district is considered "Ever 4DSW" if they ever have one school with 4DSW. Average teacher salaries are reported in 2023 dollars.

Appendix Table A3. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Shortage Credentials (RQ1) by Treatment Cohort

	Percent of teachers (weighted by FTE) with shortage credentials								
	ATT	4DSW adoption cohort (spring year)							
		2015	2016	2017	2018	2019	2020	2021	2022
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All schools (N=1428)									
4DSW next year	0.109*	0.360*	-0.082	0.119	0.125	0.109	-0.131	0.460	-0.015
	(0.051)	(0.139)	(0.141)	(0.072)	(0.102)	(0.158)	(0.232)	(0.310)	(0.191)
Treated schools	182	2	12	33	59	10	7	21	38
Schools in small rural districts (N=90)									
4DSW next year	-0.042	0.405	-0.194	0.095	-0.127	-0.223	-0.896*	0.079	-0.362
	(0.116)	(0.229)	(0.201)	(0.155)	(0.630)	(0.246)	(0.377)	(0.332)	(0.358)
Treated schools	64	2	8	19	3	7	2	8	15
Schools in large rural districts (N=152)									
4DSW next year	0.063		0.039	0.163	-0.332***			0.123	0.225
	(0.097)		(0.122)	(0.196)	(0.081)			(0.261)	(0.230)
Treated schools	50	0	4	10	5	0	0	12	19
Schools in non-rural districts (N=1121)									
4DSW next year	0.251**				0.194*	0.637	0.201	6.349***	-0.214
	(0.092)				(0.092)	(0.685)	(0.410)	(0.333)	(0.681)
Treated schools	61	0	0	0	51	3	2	1	4

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

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22.

Appendix Table A4. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Teachers (FTE) who Move Districts in Colorado (RQ2a) by Treatment Cohort

	Percent of teachers (weighted by FTE) FTE who move districts in Colorado								
	ATT	4DSW adoption cohort (spring year)							
		2015	2016	2017	2018	2019	2020	2021	2022
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All schools (N=1420)									
4DSW next year	-0.857	-30.529**	0.482	-1.456	0.885	-1.063	-3.066*	0.302	-1.573
	(0.653)	(11.430)	(1.547)	(0.924)	(0.578)	(1.699)	(1.471)	(1.281)	(0.918)
Treated schools	182	2	12	33	59	10	7	21	38
Schools in small rural districts (N=89)									
4DSW next year	-2.659	-31.080*	-1.752	-0.899	0.552	-1.054	-0.559	3.822	-3.070
	(2.144)	(11.895)	(2.901)	(3.228)	(6.868)	(2.721)	(3.911)	(4.344)	(3.792)
Treated schools	64	2	8	19	3	7	2	8	15
Schools in large rural districts (N=150)									
4DSW next year	0.942		3.125	0.563	3.076			-0.380	-2.218
	(0.847)		(3.205)	(0.855)	(2.196)			(1.586)	(1.547)
Treated schools	50	0	4	10	5	0	0	12	19
Schools in non-rural districts (N=1117)									
4DSW next year	0.765				0.837	0.542	-0.304	2.140*	-2.282
	(0.617)				(0.656)	(2.203)	(2.581)	(0.944)	(1.319)
Treated schools	61	0	0	0	51	3	2	1	4

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

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22.

Appendix Table A5. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Teachers (FTE) who Leave Teaching or the State (RQ2b) by Treatment Cohort

	Percent of teachers (weighted by FTE) who leave teaching or the state								
	ATT	4DSW adoption cohort (spring year)							
		2015	2016	2017	2018	2019	2020	2021	2022
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All schools (N=1420)									
4DSW next year	0.263	0.126	-2.061	1.517	-0.213	-0.188	3.053*	3.053	-1.534
	(0.564)	(11.368)	(2.787)	(0.836)	(0.634)	(1.218)	(1.552)	(1.958)	(2.265)
Treated schools	182	2	12	33	59	10	7	21	38
Schools in small rural districts (N=89)									
4DSW next year	-1.901	2.217	-1.421	-3.406	4.223	-7.223	-1.750	2.940	1.930
	(2.484)	(11.680)	(5.951)	(3.019)	(7.012)	(5.492)	(5.700)	(4.170)	(5.912)
Treated schools	64	2	8	19	3	7	2	8	15
Schools in large rural districts (N=150)									
4DSW next year	0.367		-0.237	-0.990	2.309			3.028	-0.376
	(0.946)		(1.592)	(1.687)	(3.070)			(1.939)	(2.938)
Treated schools	50	0	4	10	5	0	0	12	19
Schools in non-rural districts (N=1117)									
4DSW next year	-0.329				-0.424	2.527	4.188*	3.661*	-11.577
	(0.592)				(0.640)	(1.944)	(1.737)	(1.422)	(8.508)
Treated schools	61	0	0	0	51	3	2	1	4

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

Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22.

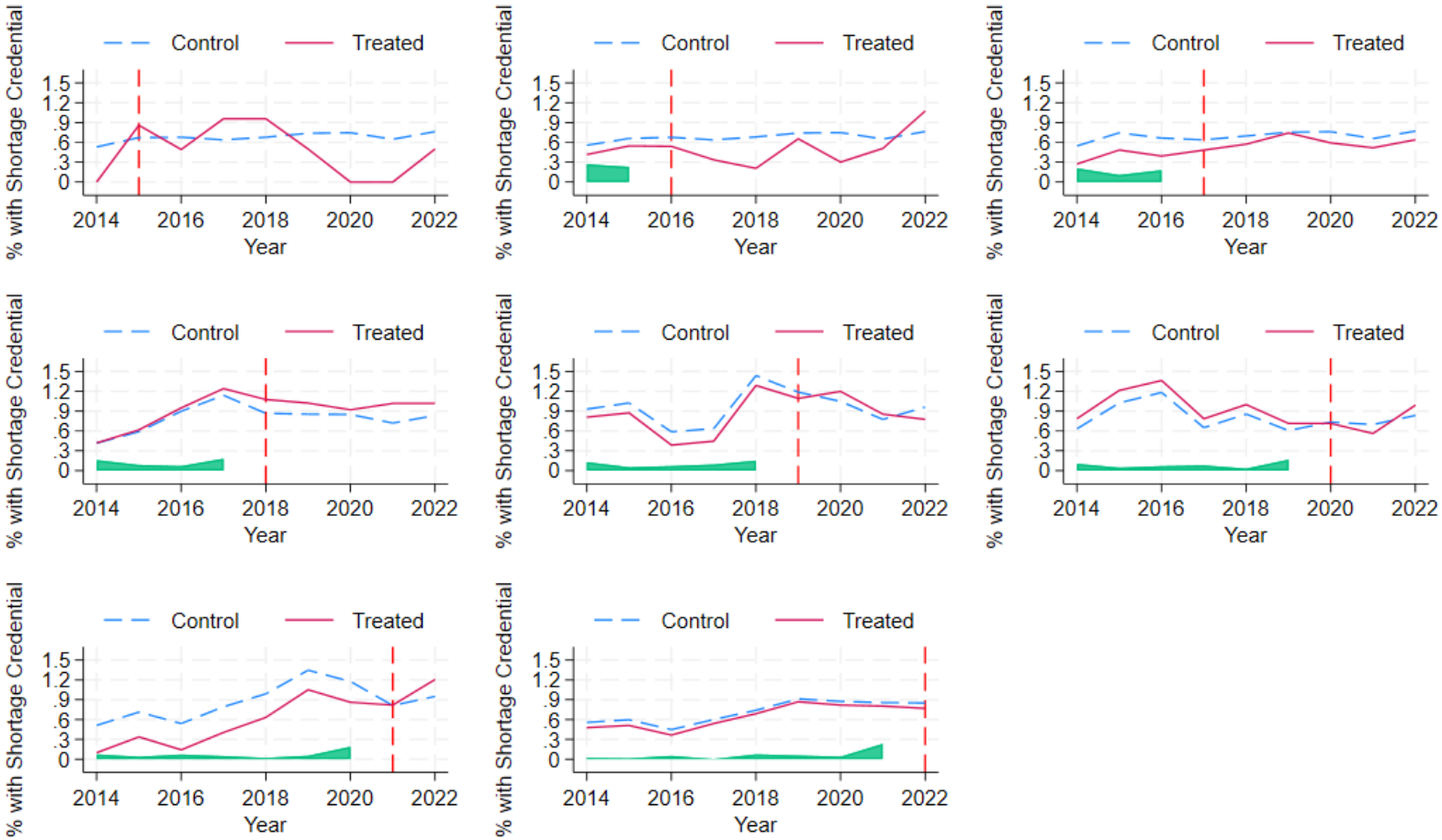
Appendix Table A6. Synthetic Control DiD Estimates of 4DSW Effects on Student Average Daily Attendance (RQ3) by Treatment Cohort

	Average Daily Attendance (ADA)													
	ATT	4DSW adoption cohort (spring year)												
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
All schools (N=1373)														
4DSW same year	0.109*	0.427	-0.560	-1.105	1.301	1.725***	0.978**	-0.462	1.904**	-0.349	0.514	0.784	0.514	2.909
	(0.051)	(0.384)	(0.591)	(0.491)	(1.048)	(0.487)	(0.359)	(0.796)	(0.687)	(0.272)	(0.623)	(1.062)	(0.297)	(2.101)
Treated schools	242	39	9	24	4	7	2	7	30	55	10	7	20	28
Schools in small rural districts (N=100)														
4DSW same year	-0.238	-0.735	-1.386	-2.307*	1.312	0.073	-1.477	-0.458	1.155	-1.590	-0.267	-1.367	0.460	4.512
	(0.572)	(1.167)	(0.926)	(0.925)	(2.647)	(1.146)	(1.026)	(0.962)	(1.552)	(1.093)	(0.53)	(1.132)	(0.656)	(3.365)
Treated schools	77	10	6	2	2	7	2	3	17	3	7	2	7	9
Schools in large rural districts (N=159)														
4DSW same year	-0.758*		0.252	-1.248				-1.713	0.277	-1.372**			0.688	0.008
	(0.372)		(1.137)	(0.623)				(1.235)	(0.280)	(0.441)			(0.448)	(0.651)
Treated schools	67	0	3	18	0	0	0	4	9	5	0	0	12	16
Schools in non-rural districts (N=1040)														
4DSW same year	0.381	0.633			0.379					0.159	-0.692	-2.603***	1.265	5.625
	(0.341)	(0.600)			(0.678)					(0.382)	(0.481)	(0.298)	(0.943)	(4.131)
Treated schools	78	20	0	0	2	0	0	0	0	47	3	2	1	3

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

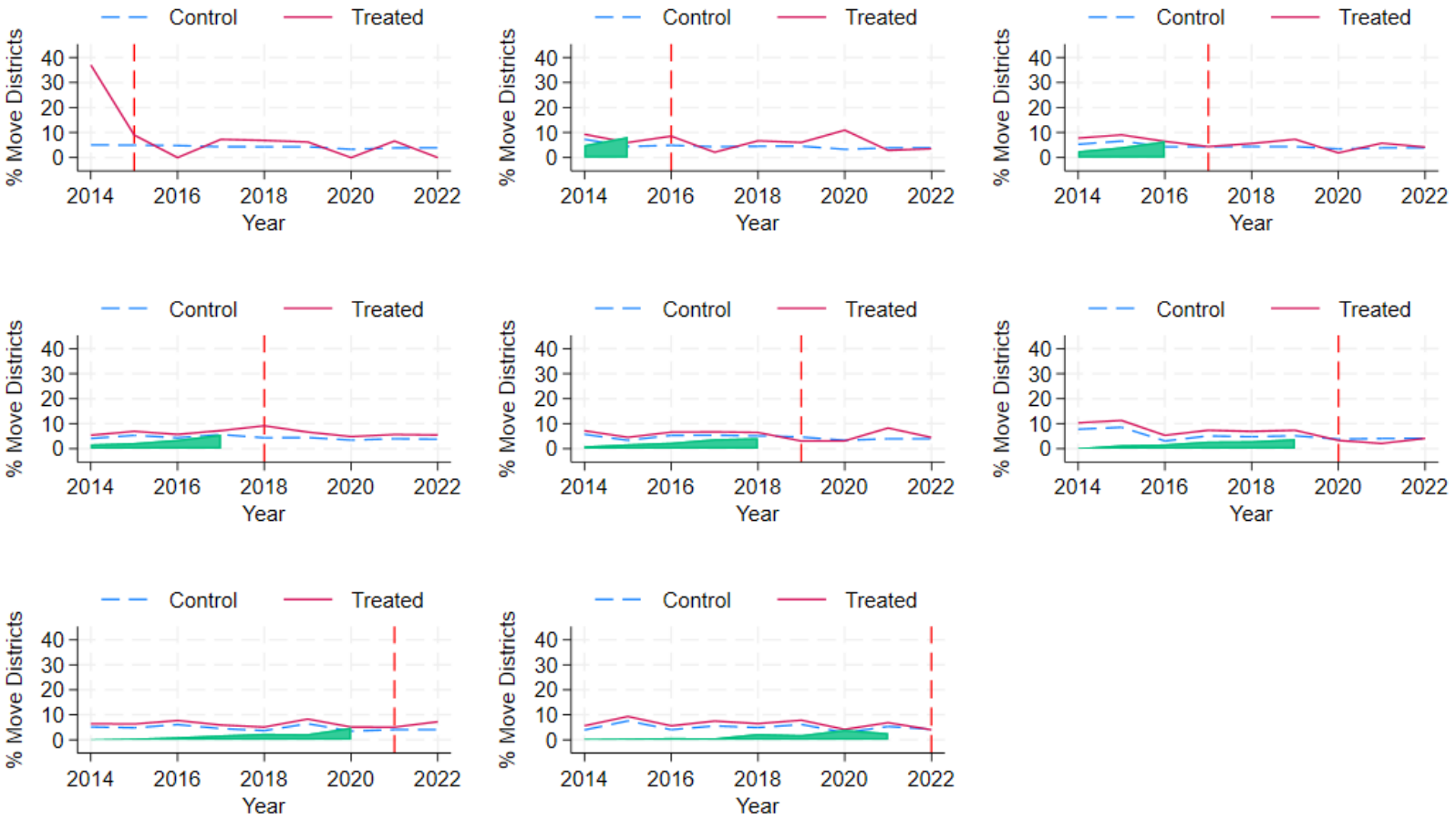
Note. Data are from the Colorado Department of Education and the Common Core of Data from 2010-11 to 2022-23.

Appendix Figure A1. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Shortage Credentials (RQ1) by Treatment Cohort



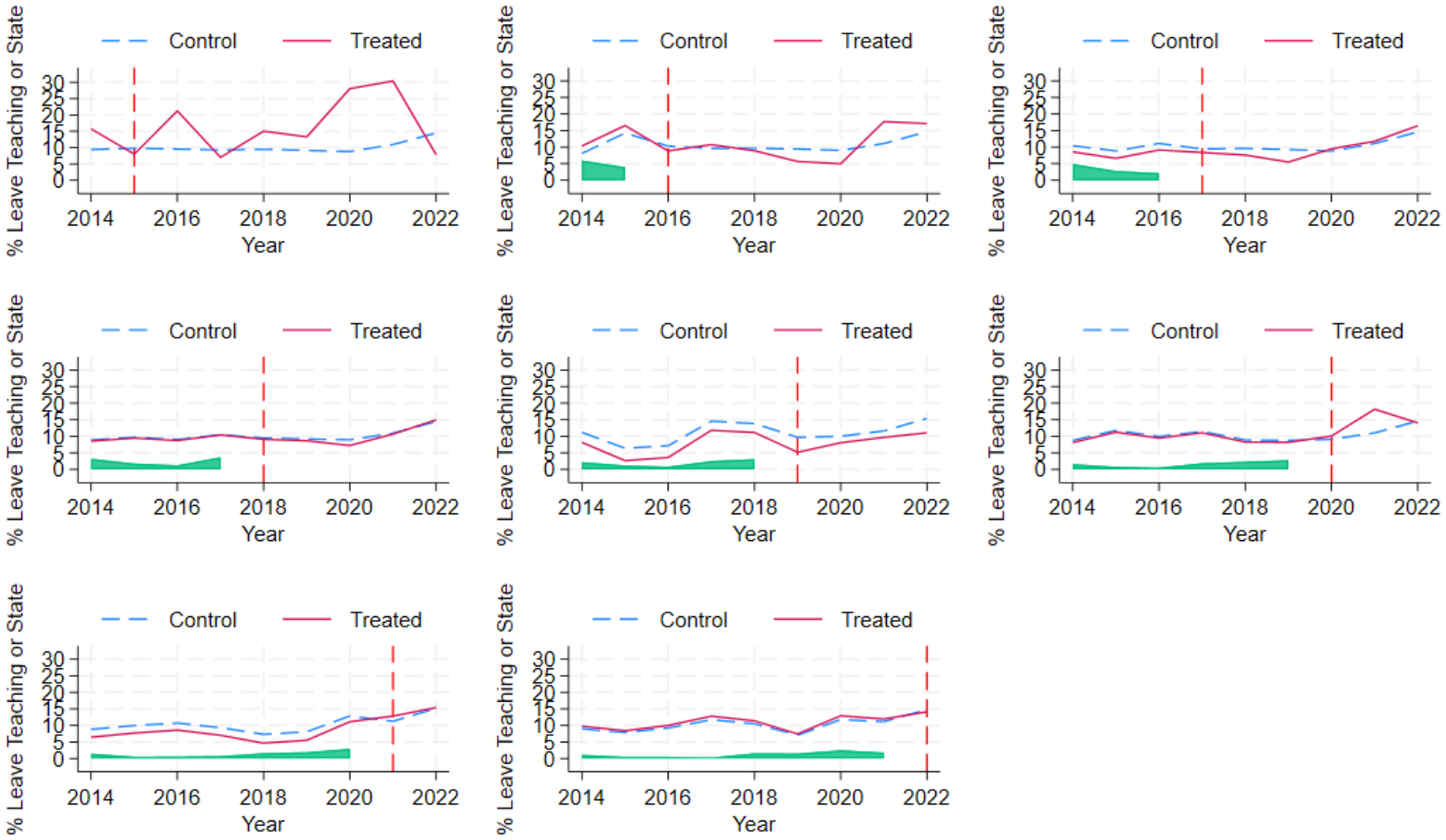
Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22. Treated districts represent districts that adopt the 4DSW during the study period, and control districts represent districts that never adopt a 4DSW. The shaded green area in each figure represents the time-specific "lambda" weights for each pre-treatment year in each cohort analysis.

Appendix Figure A2. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Teachers (FTE) who Move Districts in Colorado (RQ2a) by Treatment Cohort



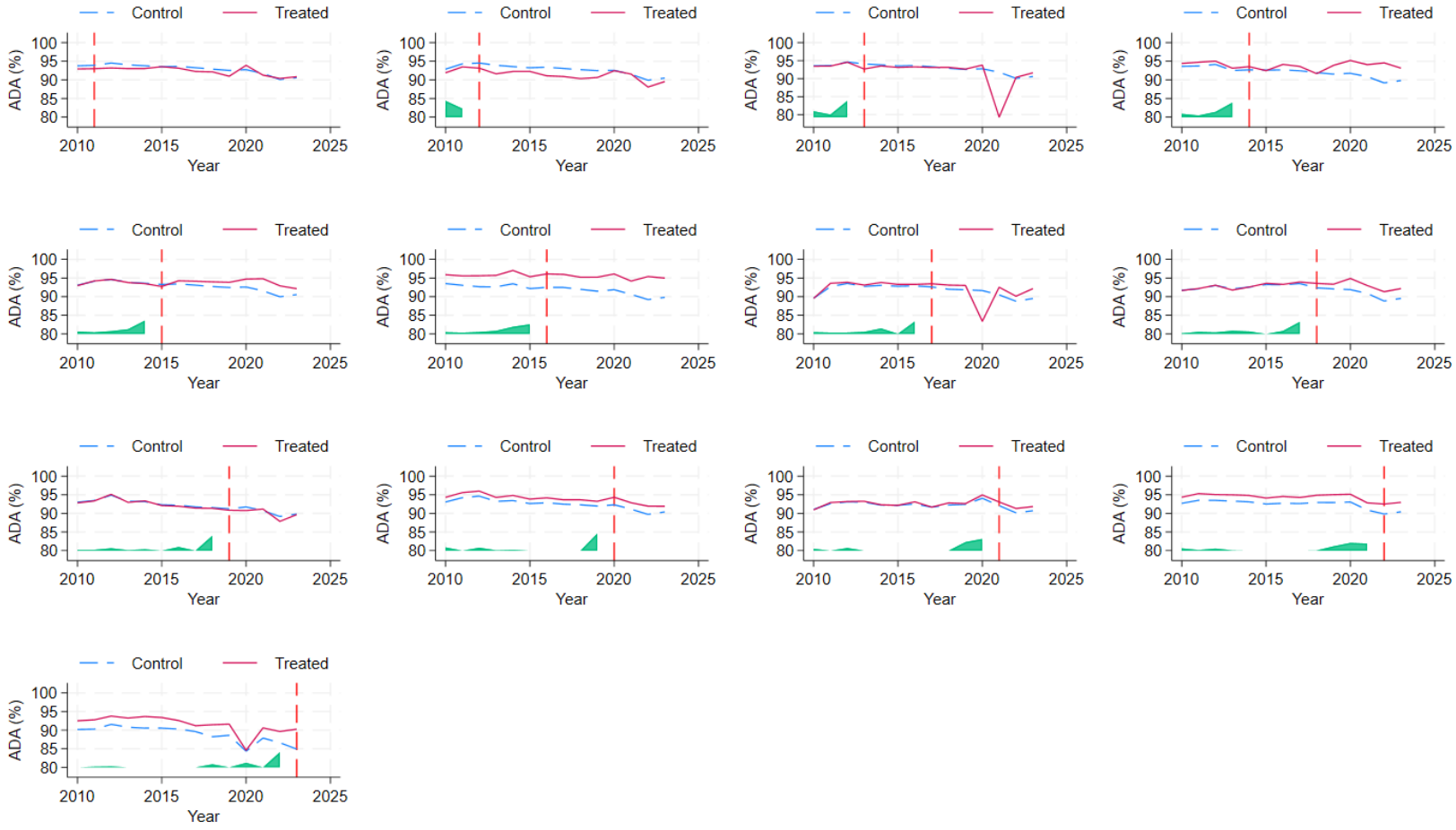
Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22. Treated districts represent districts that adopt the 4DSW during the study period, and control districts represent districts that never adopt a 4DSW. The shaded green area in each figure represents the time-specific "lambda" weights for each pre-treatment year in each cohort analysis.

Appendix Figure A3. Synthetic Control DiD Estimates of 4DSW Effects on the Percent of Teachers (FTE) who Leave Teaching or the State (RQ2b) by Treatment Cohort



Note. Data are from the Colorado Department of Education and the Common Core of Data from 2013-14 to 2021-22. Treated districts represent districts that adopt the 4DSW during the study period, and control districts represent districts that never adopt a 4DSW. The shaded green area in each figure represents the time-specific "lambda" weights for each pre-treatment year in each cohort analysis.

Appendix Figure A4. Synthetic Control DiD Estimates of 4DSW Effects on Student Average Daily Attendance Rate (RQ3) by Treatment Cohort



Note. Data are from the Colorado Department of Education and the Common Core of Data from 2010-11 to 2022-23. Treated districts represent districts that adopt the 4DSW during the study period, and control districts represent districts that never adopt a 4DSW. The shaded green area in each figure represents the time-specific "lambda" weights for each pre-treatment year in each cohort analysis.