What happens when you combine high school and college? The impact of the early college model on postsecondary performance and completion[1]

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The U.S. economy is dramatically changing in the 21st century with new, emerging careers, most of which will require some schooling beyond high school (Carnevale & Desrochers, 2003; Carnevale, Smith, & Strohl, 2010). Yet too many high school students do not enroll in and graduate from college; out of an estimated 70 percent of high school graduates who immediately enter postsecondary education, only about half (49 percent) attain some type of postsecondary credential within six years (Ross et al., 2012). The problems are particularly acute for students with fewer means (Bailey & Dynarski, 2011; Louie, 2007). For example, first generation college-goers are almost half as likely to go to college and to obtain a degree as students whose parents attended college (Redford & Hoyer, 2017). Bachelor's degree attainment rates for Black and Hispanic students are approximately 20 percentage points lower than for white students (Ross et al., 2012). This means that many individuals are currently shut out of the opportunities and advantages that postsecondary education can bring.

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Educators and policymakers have been seeking to increase the number of students enrolling and succeeding in college by implementing a variety of interventions at both the high school and postsecondary levels. High school-level activities have included efforts such as: changing the high school graduation requirements to increase students' likelihood of completing the courses needed for college (Edmunds & McColskey, 2007; Tierney, Bailey, Constantine, Finkelstein, & Hurd, 2009); interventions designed to build students' aspirations to go to college and their college readiness skills (Swanson, Mehan, & Hubbard, 1995); expanding access to college-level courses through dual enrollment and Advanced Placement (Iatarola, Conger, & Long, 2011; Long, Conger, & Iatarola, 2012; Speroni, 2011); and providing assistance to help students complete the logistical steps associated with applying to and enrolling in college (Castleman, Owen, & Page, 2015; Castleman, Page, & Schooley, 2014). Postsecondary-level interventions include tutoring and counseling, financial aid, efforts to increase students' belonging in college, as well as more comprehensive interventions that combine multiple factors, such as "living and learning communities" or interventions that couple financial aid with required academic supports (Anderson & Goldrick-Rab, 2018; Angrist, Autor, Hudson, & Pallais, 2016; Denning, Marx, & Turner, forthcoming; Perna & Leigh, 2018). These interventions are primarily targeted at addressing specific student needs and are done within the current system that keeps high school and college as separate entities.

Early college high schools ("early colleges" for short) are a different approach that integrates practices designed to promote postsecondary success while combining the high school and college experience. Serving students in grades 9 through 12 or 13, early colleges are targeted at students who are underrepresented in college, such as low-income students, students who are the first in their family to go to college, and students who are members of racial and ethnic

minority groups. Students begin their engagement in the postsecondary experience early with many students taking at least one college course as early as 9th grade. By the time students are juniors or seniors in high school, most of their courses are college courses and they spend most of their day interacting with other college students. The expectation is that early college students will graduate with both a high school diploma and an associate degree or two years of college credit. Thus, students are expected to accomplish in four to five years what would normally take them at least six years (four years of high school plus two years of postsecondary education).

The early college model in North Carolina (one of the states to most fully embrace the model) has been the subject of a twelve-year longitudinal experimental study that has found a variety of positive impacts at both the high school and postsecondary levels. Early college students were more likely to successfully complete a college preparatory course of study (Edmunds, Arshavsky, & Fesler, 2015; Edmunds, Bernstein, Unlu, Glennie, Willse, et al., 2012). They also had higher attendance, fewer suspensions, and were more likely to graduate from high school than students in the control group (Edmunds, Bernstein, Unlu, Glennie, Smith, et al., 2012; Edmunds, Willse, Arshavsky, & Dallas, 2013). Finally, the study found that early college students enrolled in postsecondary education at higher rates and preliminary findings showed that they were more likely to receive an associate degree within six years of entering high school (Edmunds, Unlu, et al., 2017). The enrollment and associate degree findings were replicated in a national study of 10 early colleges (Berger, Turk-Bicakci, Garet, Knudson, & Hoshen, 2014; Berger et al., 2013).

Despite the positive impacts on these outcomes, there are still questions about how well this truncated educational experience will serve students once they graduate from the early college and pursue additional postsecondary education on their own. Some postsecondary faculty

may worry that, by shortening the total amount of education time, students are missing core knowledge and skills that are essential for performing well in college. Early college advocates may respond that their students will be just as well, if not better, prepared than traditional students because of the schools' emphasis on rigorous instruction, comprehensive supports, and early access to college courses. This paper is designed to test these competing hypotheses by examining the impact of the early college on students' performance in postsecondary education after they leave the early college. Specifically, we are examining the impact of the early college on students' attainment of a postsecondary credential within four years after 12th grade and their postsecondary Grade Point Average (GPA). Answering these questions will help determine whether a combined high school-college experience could serve as a viable path for increasing students' successful completion of postsecondary education.

THEORETICAL FRAMEWORK

Researchers have argued that students' success in college is a longitudinal process (Perna & Thomas, 2006), driven substantially by the background and experiences they bring with them (Tinto, 1993), including their academic knowledge and skills, their organizational and study skills, and their cultural capital, which includes an understanding of how to navigate college. We begin by examining these factors and then describe how the early college environment is designed to address them. We conclude by discussing the unique structure of the early college and the potential advantages and disadvantages associated with it.

Factors Associated with Success in College

Students' level of incoming academic achievement and preparation are strongly associated with success in college. Students' grades in high school and scores on standardized tests are positively associated with college grades and successful completion of college (ACT

Inc., 2008; Geiser & Santelices, 2007). Additionally, one of the strongest predictors of success in college is the extent to which students take more advanced high school courses (Adelman, 2006; Adelman, Daniel, & Berkovits, 2003). From at least the early 1900s, colleges themselves have used the type and level of courses that students take in high school as an indicator of whether a student is ready for college, expecting that students take what is now commonly known as a college preparatory course of study (Finkelstein & Fong, 2008; Krug, 1969). In addition to academic content knowledge, researchers have also argued that students' success in college is dependent upon the level of a variety of academically-oriented skills including critical thinking, the ability to read and write effectively and problem-solving (Conley, 2005, 2007, 2008; Edmunds, Arshavsky, et al., 2017).

Success in college also depends on students' ability to adapt to a different cultural environment that requires students to be able to operate more independently (Hooker & Brand, 2010). Thus, skills such as time management, organizational management, study skills, the ability to collaborate with others, and the ability to advocate for oneself take on increasing importance (Byrd & MacDonald, 2005; Conley, 2007) but these are areas in which underrepresented populations, such as first generation college-goers, may struggle (Collier & Morgan, 2008; Roderick, Nagaoka, & Coca, 2009). Some students come with a better understanding of what it means to be a college student, bringing with them the cultural capital that comes from their family members' academic history or parental coaching on how to behave and what to expect in college (Collier & Morgan, 2008).

A third area associated with success in college is students' ability to navigate the college environment, including registering for classes, understanding the process of applying for financial aid, and understanding majors and graduation requirements. These are processes that

can be confusing and unclear, particularly for low-income or first-generation students (Roderick, Nagaoka, Coca, & Moeller, 2008). For example, an estimated one in five low-income students who were enrolled in college and would qualify for financial aid never applied for it (Roderick et al., 2009).

As implemented in North Carolina, the early college model intends to prepare students for success in college on many of these fronts. The next section describes the early colleges and the strategies they use to promote postsecondary success.

Early College Model

Early colleges, as studied in this project, are small schools of choice that combine the high school and college experiences and are located on college campuses, primarily on community college campuses. The schools were purposefully created to prepare all of their students for college (Edmunds, 2012), building an environment where "college readiness was not something left to chance…" (Edmunds, Arshavsky, et al., 2017, p. 129).

To prepare students academically, the early college uses a variety of approaches, two of which involve coursetaking. The first approach requires all students to take an honors-level college preparatory high school curriculum (North Carolina New Schools, 2013; Thompson & Onganga, 2011). This is intended to ensure that more students complete the courses needed for entrance to a four-year university. Results from the existing longitudinal experimental study shows that this does happen with a significantly higher proportion of treatment students successfully completing a college preparatory course of study (Edmunds, Bernstein, Unlu, Glennie, Willse, et al., 2012; Edmunds, Unlu, et al., 2015). Second, early college students receive early exposure to college courses, frequently starting in the 9th grade. As students progress through the early college model, they take more and more college courses that can help

them simultaneously meet high school graduation requirements as well as the requirements for an associate degree or, for students on a four-year university campus, meet the general education requirements of the first two years of college (Berger, Adelman, & Cole, 2010). Results from the experimental study show that early college students completed many more college credits while in high school than the control group (21.6 credits for treatment students vs. 2.8 for the control group) (Edmunds, Unlu, et al., 2017) .

Early colleges implement other strategies that prepare students with the academic and other skills necessary for success in postsecondary education. For example, the schools emphasized a set of rigorous and relevant instructional practices that required students to engage in critical thinking, extensive writing, cooperative work, and ongoing class discussion (Edmunds, Arshavsky, et al., 2017; North Carolina New Schools, 2013). As an interviewed early college student noted, "writing here at the early college gives you a step above the other college students when you get into the English class, because you know what to expect and you've already written most of these papers that they ask you to do…" (Edmunds, Arshavsky, et al., 2017, p. 131).

Early colleges also provide explicit instruction in other skills such as time management, note-taking, and study skills. Most of the schools also indicated that they focused specifically on teaching students to advocate for themselves with college faculty, scaffolding the experience to slowly build students' ability to communicate effectively with their instructors (Bruce, 2007; Edmunds, Arshavsky, et al., 2017). Students are coached through some aspects of the college navigation processes, including selecting and registering for their classes, identifying and using college resources, and utilizing online course materials, such as Blackboard (Le & Frankfort,

2011). The early colleges also provide explicit assistance in helping students through the college application process, including applying for financial aid (Edmunds, Arshavsky, et al., 2017).

Finally, the early college model recognizes that the increased expectations must be accompanied by increasing support (Jobs for the Future, 2008). As a result, schools focus on developing a comprehensive suite of academic and affective supports (Born, 2006; Le & Frankfort, 2011). Results reported elsewhere indicate that early college students noted higher levels of support than control students (Edmunds et al., 2013).

Figure 1 displays the mechanisms by which the early college is expected to increase students' postsecondary performance.

FIGURE 1 HERE

The Unique Structure

The early college thus incorporates a comprehensive suite of practices and supports that are associated with students' success in college. Given the model's components, it is reasonable to expect that the early college will result in increased performance in postsecondary education. Nevertheless, as noted earlier, the unique structure of the early college means that high school and college are essentially happening at the same time. The end result is that the early college is truncating what would normally take six years (four years of high school plus two years of college) into either a four or five-year experience.

This approach builds on a longstanding argument that there is overlap between parts of the high school and college experiences that can be consolidated (Krug, 1969; Wechsler, 2001). For example, as far back as the early 1900s, Stanford University president David Starr Jordan argued that the instruction of college's first two years "is of necessity elementary and of the same general nature as the work of the high school itself" (McDowell, 1919, p. 18). Nevertheless, the idea of combining portions of high school and college never took extensive hold, reflecting

countervailing beliefs that a full four years of high school were necessary to provide comprehensive academic preparation and enrichment (Wechsler, 2001).

As a result, it is still an open question about whether combining the high school and college experience, thereby shortening the two, will provide students with sufficient academic preparation to be successful in college. Additionally, it is possible that high school students may be unsuccessful in their college courses, which might discourage them from future postsecondary education or might make them less likely to succeed. For example, one qualitative study found that early college students who had poor performance in a college biology class later lost interest in biology and the sciences when they enrolled in the local university (Alaie, 2011).

This paper is therefore designed to examine two competing scenarios relative to the early college. The first scenario is that a combined high school and college experience, supplemented by comprehensive and purposefully focused practices and supports, can adequately prepare students for further postsecondary education. These supports may especially be instrumental for the postsecondary enrollment, persistence, and degree acquisition of first generation college goers and students from disadvantaged backgrounds. The second scenario is that, despite the additional supports, the shortened time spent in a high school/college combination and completion of a substantial portion of the first two years of college coursework while in high school may result in significant omissions in students' preparation that would reduce their likelihood of success. This adverse effect may be more prevalent for students who would have pursued postsecondary education even in the absence of the early college model. We explore these two scenarios by looking at the impact of the early college model on students' performance in postsecondary education and their attainment of a postsecondary credential.

METHODOLOGY

This study is based on a multi-site randomized field trial designed to examine the impact of early colleges on core student outcomes. The purpose of this paper is to examine the impact of the model on students' performance in postsecondary education. The specific research questions are:

1. What is the impact of the early college on students' attainment of postsecondary credentials?
2. How do these impacts differ for students who are low-income, first in their family to go to college, members of underrepresented minority groups, and students who enter high school below grade level?
3. What is the impact of the early college on students' postsecondary performance, as measured by students' GPA in four-year institutions?

Early colleges included in this study utilized a lottery to select students from an applicant pool, and the study compares the students assigned to the treatment group (early college) with students assigned to the control group (generally the traditional high school in the district, or "business as usual"). This research methodology has been used to look at the majority of impacts from this study (Edmunds, Arshavsky, et al., 2017; Edmunds, Bernstein, Unlu, Glennie, Willse, et al., 2012; Edmunds, Unlu, et al., 2017; Edmunds, Unlu, Glennie, & Tsai, 2018; Edmunds et al., 2013) and was used to answer the question concerning postsecondary credential attainment.

Analyses estimating the impact of the early college model on postsecondary degree attainment were conducted within this experimental framework; however, we were unable to use the experimental design for the four-year GPA outcomes for a variety of reasons. First, GPA requires transcript-level data, which was only available for students who enrolled in the University of North Carolina system. Second, earlier results indicated that early college students

had higher enrollment than control students in four-year institutions. Both issues indicate that the treatment and control group students were likely not comparable; as a result, we chose to use a quasi-experimental matching approach within the original randomized sample, described in more depth below.

Sample

The early colleges examined in this paper are located in rural and urban settings in all regions of North Carolina. On average, they are much smaller than the traditional schools in their counties but serve students who are similar to the student populations in their districts in terms of eligibility for free- and reduced-price lunch and race/ethnicity. The early colleges do have much lower enrollments of students with disabilities and they enroll students with higher initial levels of achievement. While early colleges and traditional high schools have similar teacher turnover rates, early colleges are much more likely to have teachers who are in their first three years of teaching.

Schools in the study had to agree to use a lottery to select their students. Students applied to the early college and then underwent a screening process designed independently by each school, resulting in a pool of eligible students. The eligible students were then entered into a lottery where students were either offered a spot to attend the early college (treatment group) or were not offered a spot and attended the business-as-usual condition, usually the comprehensive high school in the district (control group). Within this overall sample, the specific analytic samples were different for the two outcomes and are described along with the outcomes below.

Measures and Data Sources

Outcome Measures

This study focused on students' performance in postsecondary education after they left the early college, examining the impact on two primary outcomes: attainment of a postsecondary credential and postsecondary Grade Point Average (GPA).

Postsecondary credentials. Successfully completing postsecondary education is one of the key goals of the early college model. The primary outcome examined for this study is attainment of any postsecondary credential including bachelor's degrees, associate degrees, and technical credentials but we also present separate results for each degree type. We examined students' attainment of these degrees by the end of the fourth year after 12th grade, giving students who enrolled in college directly after high school four years to complete their degree. We do recognize that many researchers and policymakers allow for six years for on-time completion of a bachelor's degree; however, because we are following students in real time, this is the farthest time point for a large sample of students.

The data source for degree attainment is the National Student Clearinghouse (Clearinghouse). The Clearinghouse collects data representing approximately 94 percent of students enrolled in postsecondary institutions in the United States, including 96 percent of four-year institutions and 99 percent of two-year institutions in North Carolina (National Student Clearinghouse Research Center, 2013), and provides information about enrollment by semester, the institution in which a student is enrolled, and type and date of any degrees received. The Clearinghouse linked our applicant data to their files using name and birth date.

If a student did not have a degree in the Clearinghouse data, we considered him or her not to have earned one. We acknowledge that a student could be missing from the Clearinghouse

data for a variety of reasons beyond non-enrollment or non-degree attainment. The primary other reasons include misidentification or a student opting out of sharing his or her data (Dynarski, Hemelt, & Hyman, 2015). We undertook various approaches to minimize these reasons, including resubmitting the same list of names for multiple years since students' permissions can change over time (Dynarski et al., 2015) and submitting various spellings of the same name (e.g., John, Jon, Jonathan, Jonathon, etc.). While this approach ensures that we have outcome data for all randomized students (i.e., virtually no overall or differential attrition) and the outcomes are defined in the same way for both treatment and control groups, numerically more treatment students may be affected by the incompleteness of degree acquisition data in the Clearinghouse if, as we expect, more treatment students enroll in postsecondary education. As a result, our impact estimates may be considered conservative.

The sample used for the postsecondary credential analyses includes a total of 2969 students who applied to 19 early colleges in North Carolina from 2005-2006 through 2009-2010 and represent all of the students in the sample who were four years after 12th grade by the fall of 2017, when these data were collected. The analytic sample includes 1703 treatment and 1266 control students. The baseline characteristics of the sample are shown in Table 1, which indicates that the differences between the treatment and control groups are small and not statistically significant for almost all variables, as expected from groups constructed using random assignment. Nevertheless, all analyses that compare outcomes of treatment and control students control for all of these characteristics.

TABLE 1 HERE

Grade-point Average. As a measure of how well students are doing in courses after they leave the early college, we look at students' GPA for all college courses they had taken since

entering the UNC system after graduation from the early college. Specifically, we examine cumulative GPA measures at four time points: 1) through six years after enrolling in ninth grade (i.e., grade 14); 2) through seven years after enrolling in ninth grade (grade 15); 3) through students' first year at the UNC system, and 4) through students' second year at the UNC system. Using multiple measures defined at different time points allows us to examine GPA in a comprehensive and flexible manner, accounting for the wide variation across when students enrolled in the UNC system. For example, some students enrolled in the UNC system right after completing high school (grade 13) while some students enrolled after spending two years in a two-year institution (grade 15). Cumulative GPA in grade 14 and grade 15 aim to hold constant students' age and the time after they enrolled in high school while cumulative GPA through the first and second year at the UNC system aim to hold constant the time students spent in the UNC system.

The analytic sample for each of these time points differ according to which students were enrolled in the UNC system and had course enrollment data at that particular time point. That is, we cannot use the fully randomized sample of students because a given grade measure is not defined for students who were not enrolled in the UNC system by that particular time point. For students who were enrolled in a 4-year college outside the UNC system, we cannot measure GPA reliably either and set their GPA to missing. Given the relatively large proportion of students with missing GPA (between 68 percent and 74 percent), we did not impute missing values for this outcome.

Another factor complicating the GPA analyses was that having a non-missing GPA measure could have been directly related to the treatment. For example, cumulative GPA through grade 14 was missing for 69 percent of the treatment students while it was missing for 76 percent

of the control students. This was likely a direct result of the positive impact of the treatment on students' enrollment in 4-year institutions. Because of the large overall and differential missing rates for the GPA measures, we treated these analyses as quasi-experimental and employed propensity score matching methods to conduct the GPA analyses with comparable treatment and control students, described in the analysis section below.

Covariates

The outcome measures created using the Clearinghouse and UNC system data were linked to student application data (which included treatment/control status and odds of being selected to the early college) and data from the North Carolina Department of Public Instruction (NCDPI). NCDPI data included baseline covariates such as demographic characteristics (gender, race/ethnicity), economically disadvantaged status, 8th grade achievement scores, and special education status. The propensity score analysis conducted for the GPA measures utilized additional measures including 8th-grade absences, teachers' assessment of students reading and math achievement in 8th grade, performance score for the 8th-grade school, district-level average high school graduation rates, and number of colleges within 8th-grade county. The missing values for each covariate were imputed using the dummy variable method, which entails replacing the missing values with the sample mean of the covariate and including a dummy variable for each imputed record. The data were linked and stored at the North Carolina Education Research Data Center housed at Duke University.

Subgroups

Early colleges were specifically designed to increase postsecondary access and success for students for whom access to college has historically been problematic. As a result, we examined the impact for four different sub-groups:

1. Underrepresented minorities. Students who are members of specific racial and ethnic minority groups are less likely to complete postsecondary education (McFarland et al., 2018). As a result, we explore the impact of the model on students who are members of minority groups underrepresented in the North Carolina university system, which includes students who identify as African-American, Hispanic/Latino, or Native American. Students who are White, Asian, or Multiracial are not considered as underrepresented.
2. First generation college-goers. Another target population of the early college model, first generation college students are also much less likely to graduate from college (Redford & Hoyer, 2017). For our study, we defined first generation students as those whose parents had no exposure to postsecondary education. Students whose parents enrolled for any length of time in a two- or four-year college were not considered first generation.
3. Low-income students. The third target population is low-income students, a group that also faces substantial challenges in enrolling and succeeding in college (Bailey & Dynarski, 2011). These students are defined as those who qualify for free and reduced-price lunch. Because high school students are less likely to enroll in free lunch programs (Riddle, June, 2011), we use students' 8th-grade free and reduced-price lunch classifications to define this subgroup.
4. Not prepared for 9th grade. The final subgroup is composed of those students who have lower academic achievement. Many practitioners have concerns about whether lower-performing students can succeed in a model that accelerates them quickly into college courses; these students may even be screened out of some early colleges in North Carolina and elsewhere. As a result, we believed it was important to examine this sub-

group, which we define as students who did not pass the 8th-grade North Carolina standardized reading exam, the 8th-grade math exam, or both. Students in this sample would have received a Level I or II in reading, math, or both, which are counted as failing in North Carolina's end of grade exams. It should be noted that very few of these early college applicants had received a Level I, which would be considered substantially low-performing.

Statistical Methods

This section first describes the propensity score matching process used to create comparable treatment and control groups for analyzing GPA measures. We then describe the statistical approach used to estimate the impact of early colleges on attainment of a postsecondary credential and GPA.

Matching for GPA

To obtain comparable subsamples of treatment and control students with non-missing GPA values, we matched control students with valid GPA measures with similar treatment students with valid GPA measures using propensity score matching. Comparing the outcomes of the resulting groups is expected to inform the effect of the early colleges on GPA for students who would have enrolled in the UNC system even in the absence of the program, which is what their matched control counterpart did. Matching was implemented separately for each of the four GPA measures through the following steps:

- *Estimation of the propensity scores:* We specified a logistic model for having a valid GPA and being in the control group as a function of baseline covariates that are considered to predict GPA and enrolling in an UNC campus (which is a condition for having a valid GPA). The baseline predictors used included demographics (race/ethnicity,

gender, age, economic disadvantage, first generation college going status, having a disability, being gifted), baseline indicators of student achievement (being retained in a prior grade, scores in 8th grade math and reading end of course exams, and passing Algebra I in 8th grade, teachers' assessment of 8th-grade achievement in math and reading), 8th-grade absences (proxy for academic engagement and motivation), and regional factors that we hypothesize to be related to enrolling in UNC such as quality of the 8th-grade middle schools, district-level average high school graduation rates (measured at baseline), and number of colleges in the 8th-grade county.

- *Conducting matching:* There are many variants of propensity score matching (Caliendo & Kopeinig, 2008; Smith & Todd, 2005; Stuart, 2010). We experimented with different methods and decided to use "radius matching" which yielded the most closely balanced matched treatment and control students[2]. This method entailed matching each control students with a valid GPA with all treatment students with valid GPA measures whose propensity scores was within the pre-specified caliper of his or her score (±0.1 of the standard deviation of the propensity scores[3]). Control and treatment students who were not matched with a counterpart from the other group were excluded from the analyses. Matching was conducted with replacement and matching weights accounted for the fact that some treatment students were matched with multiple control students and vice versa.
- *Assessing quality of matches*: Following Rosenbaum and Rubin (1985) and the What Works Clearinghouse (2018), we assessed the quality of the matches using standardized

[2] For parsimony, results from alternative matching techniques are not presented in this paper but they are available upon request.

[3] This caliper value retained most of the control and treatment students in the matched groups and produced tightly balanced groups. We found that a smaller caliper value was not optimal as it left a larger proportion of treatment and control students unmatched but only slightly increased the balance. Similarly, a larger caliper only slightly decreased the proportion of unmatched students but distorted the balance.

differences between the matched treatment and control students (aka effect sizes) for each of the matching covariates. To establish baseline balance between the treatment and matched comparison students, we required he standardized differences to be less than 0.1 standard deviations in absolute value for all matching variables (which is a more stringent threshold than the 0.25 standard deviations adopted by the WWC).

Table 2 shows the sizes and characteristics of the samples for each of the four outcomes we examined. The first column under each outcome shows the treatment and control differences before matching and the second column shows the differences for the treatment and control groups after matching. Table 2 also shows the number of treatment and control students before matching and in the matched groups. These results indicate that for each outcome, only a handful of treatment and control students were not matched; there were sizeable differences between the treatment and control students prior to matching, with some differences being greater than 0.2 standard deviations; and the matching process yielded tightly balanced groups, at least on observable characteristics, with all differences being equal to or less than 0.05 standard deviations.

TABLE 2 HERE

Estimation of Impacts

Each outcome measure was used as the dependent variable in multivariate regression models that included lottery indicators, baseline covariates (demographics and measures of prior achievement listed above), and a treatment group indicator, which yielded the estimated impact of the early college on that outcome. The analyses reported in the paper were conducted in the intent-to-treat (ITT) framework, meaning that the treatment indicator captures the initial random assignment status for a given student. We do not report separate treatment-on-the-treated (TOT)

or local average treatment effect (LATE) estimates as compliance with the initial random assignment status was fairly large (92 percent among treatment students and 99 percent among control students). Because students had differing likelihoods of being selected into the treatment through the various lotteries, we included weights representing the inverse probability of a student's likelihood of being selected. We used cluster-robust standard errors calculated based on the early college or the regular high school that students attended for the longest period of time. The equation below represents a prototypical regression model:

$$Y_{ij} = \beta_1 T_{ij} + \sum_{j=1}^{J} \beta_{2j} S_j + \sum_{n=1}^{N} \beta_{3n} X_{nij} + \varepsilon_{ij}$$

where:

Y_{ij} is the outcome of interest for student i in lottery j,

T_{ij} is the treatment indicator for student i in lottery j (T_{ij} = 1 if student i is assigned to the treatment group; T_{ij} = 0 otherwise),

S_j is a lottery indicator equal to 1 for students who participated in lottery j and to 0 otherwise (j = 1...J),

β_1 is the estimated average ITT treatment effect,

β_{2j} is the fixed effect for lottery j (i.e., the average outcome of the control students from lottery j),

X_{nij} is the n-th characteristics of student i in lottery j, which is included as a covariate,

β_{3n} represents the relationship between the n-th student characteristic and the outcome Y

ε_{ij} represents a random error term for student i in lottery j.

For all outcomes, we present the adjusted impact estimate, the unadjusted control mean, and

an adjusted mean for the treatment group that is calculated by adding the adjusted impact to the unadjusted control mean. We also present the cluster-robust standard errors for the impact estimates.

The subgroup analyses were conducted by estimating a similar impact model for each subgroup of interest and the rest of the sample (i.e., separate impact models were run for first generation college-goers and non-first generation college-goers). Following Bloom and Michalopoulos (2010), we also report whether the impact for a given subgroup is statistically significantly different than the impact for the rest of the sample.

RESULTS AND DISCUSSION

The first research question pertains to the impact of the early college model on postsecondary degree attainment. The findings show that early college students received postsecondary credentials at a much higher rate than control students: by the end of the fourth year after the end of grade 12 (i.e., by grade 16), 37 percent of the treatment group is estimated to have a postsecondary credential compared to 22.2 percent of the control group (see Table 3 below). Table 3 also shows that much of that impact being driven by attainment of associate degrees (28.4 percent treatment vs. 8.8 percent control). This is not unexpected given that many of the early colleges are located on community college campuses and attaining an associate degree is a goal of the program. We also see a positive and statistically significant impact on the percentage of students attaining a bachelor's degree within four years of 12th grade (18.1 percent treatment vs. 12.8 percent control).

TABLE 3 HERE

Table 3 also shows impact on obtaining a postsecondary credential by subgroups.[4] In all subgroups, there was a positive and statistically significant impact, i.e., treatment students had larger degree attainment rates when compared to the control group. As the table also shows, however, the impacts were numerically larger for the non-targeted populations. For example, the impact for underrepresented minority students was 10.1 percentage points compared to 18.1 percentage points for non-underrepresented minority students. For most of the sub-groups, the difference between the impact on a given subgroup and that for the rest of the sample was not statistically significant, with the exception of students who were not prepared for 9th grade[5]. This suggests that the model can benefit all students but that students who are better prepared academically are also better able to take advantage of the model's acceleration.

In addition to looking at degree attainment, we also explored the amount of time it took to attain a degree. Figures 1 and 2 show the timing of two-year and four-year degree acquisition by the treatment and control students, respectively. These figures not only show that a larger number of treatment students have obtained two- and four-year degrees than control students (which is consistent with the positive impact estimates shown in Table 3), but they also indicate that treatment students obtained their degrees at a faster pace than control students. For example, Figure 2 shows that the majority of associate-degree attaining control students (about 64 percent) obtained their two-year degrees in grades 15 and 16 while the majority of associate-degree obtaining treatment students (about 76 percent) obtained their two-year degrees in grades 12 and 13. Looking at "time to degree" in another way, we find that treatment students who had earned

[4] For parsimony we present subgroup results for obtaining any postsecondary credential in the main text. Appendix A shows separate subgroup results for two-year and four-year degree attainment. These results are largely parallel to the results in Table 3.

[5] Additional analyses that explicitly tested 8th grade end of grade math and reading test scores as moderators show that a one standard deviation increase in either score is associated with about four percentage points increase in the estimated impact of the early college model.

associate degrees within eight years after 9th grade took an average of 5 years from the start of 9th grade to attain their degree while control students took an average of 6.7 years. Figure 3 depicts a similar pattern for four-year degree acquisition; of the students who have four-year degrees by grade 16, 93 percent of the control students obtained their degrees in grade 16 while almost half of the treatment students obtained their degrees in grades 14 and 15. We also find that treatment students who had earned four-year degrees within seven years after 9th grade took an average of 7.4 years from the start of 9th grade to attain their degree while control students took an average of 7.9 years. We should note that these figures provide a snapshot of time to two and four-year degrees through eight years after ninth grade (or four years after high school graduation for the typical control group student) and more students may earn degrees in later years, which will likely affect the distribution.

FIGURES 2 AND 3 HERE

The third research question explored whether early college students did better once they left the early college. Table 4 shows impacts on student performance on cumulative GPA. As the table shows, early college students performed at least as well as, if not slightly better, than control students. Among the four measures, only one —cumulative GPA through grade 14—had a statistically significant effect while the estimated impacts on the other three were smaller in magnitude and not statistically significant. These findings suggest that those treatment students who would have enrolled in the UNC system even in the absence of the early college model were just as prepared as control students but did not have a substantial advantage relative to academic preparation post high school.

TABLE 4 HERE

It is important to note that academic performance represents a partial picture of a student's readiness, albeit a very important part of that picture. As described in the literature review, there are other factors associated with students' success in college, such as ability to navigate the college system. These factors, which are supported by the early college, may not show up in academic performance but may contribute to students' attainment of postsecondary credentials.

CONCLUSION

The early college model is a new model of schooling that combines the high school and college experiences, explicitly focusing on practices and structures that are intended to increase students' success in college while also shortening the amount of time that students spend in the educational system. Essentially, the early college model is a test case of whether we can restructure the educational system in a way that embeds attainment of postsecondary credentials into high school.

At the beginning of the article, we postulated two different scenarios—one where the practices and supports prepare early college students for postsecondary success and one where the shortened time results in indirect and adverse effects on students once they leave the early college setting. Our results show that neither hypothesis is entirely correct. Results show no systematic impact on students' college GPA, suggesting that students did not appear to enter the four-year institution with either an academic advantage or disadvantage from their early college experience. Thus, the acceleration that they received was not counter-balanced by a negative impact on their preparation.

Results did show, however, that early colleges had a positive impact on the percentage of students receiving a postsecondary credential. The increase was driven in large part by increased

attainment of associate degrees, much of which was happening while students were in the early college. There was also a positive impact, however, on attainment of four-year degrees, which occurred after students left the early college. This suggests that the early college might be providing students with other benefits—beyond increased academic skills—that are influencing students' likelihood of getting a degree. One possible explanation is that the number of college credits a student receives serves as form of momentum to accomplish their degree. Another possibility is that early college students have learned more about how to navigate the college system and this is increasing the likelihood that they will attain a postsecondary credential.

It is also possible that there may be benefits from other parts of the high school experience—social aspects, participation in extra curriculars—that early college students may not receive and that may have longer term negative impacts on their social and economic well-being. Our study does not allow us to explore these possibilities, although future research may do so.

When looking at the impact on credential attainment for sub-groups, we see positive impacts for all groups, which indicates that the treatment benefitted all types of students. Looking at the increases, however, it appears that underprepared students (and to a lesser extent minority students) are benefitting at a lower rate than students who are prepared. These results indicate that the early college model is expanding access to postsecondary education for all students but that it could end up widening gaps between certain sub-groups in terms of postsecondary credential attainment.

The early college study thus provides evidence that some students can benefit from a system that combines both the high school and college experiences. At this point, there appears to be little disadvantage to the acceleration that arises from this unique approach and quite a few

advantages. However, if we seek to close income inequality gaps, it does suggest that there may need to be additional support provided to ensure that more disadvantaged populations can benefit from the model as strongly as more prepared students can.

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Figures and Tables

Figure 1: Early College Model Conceptual Framework

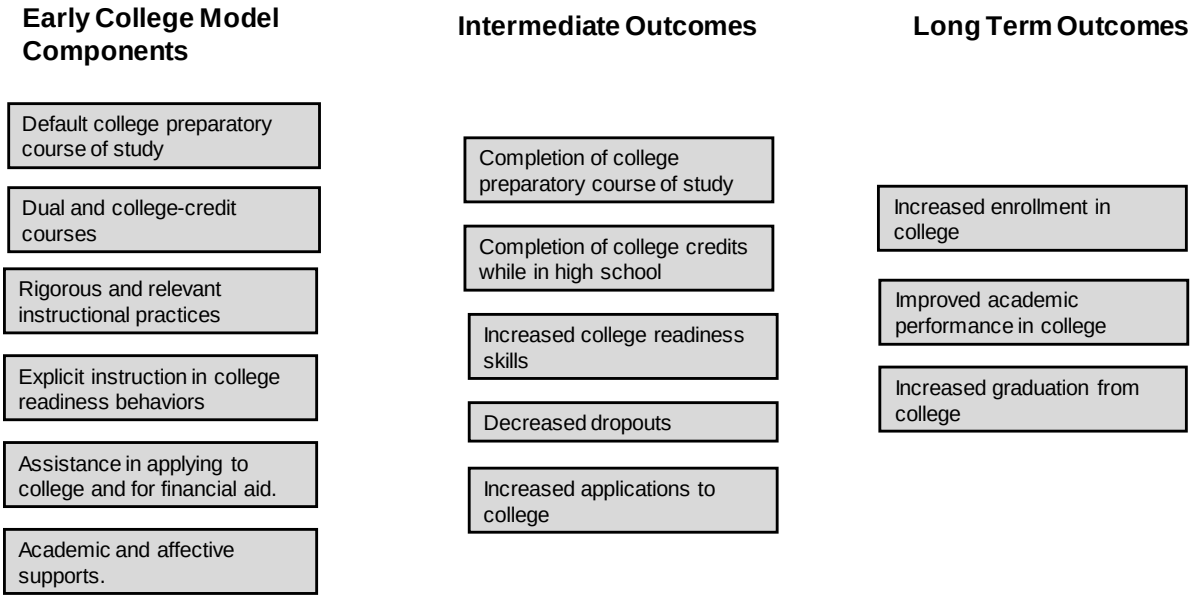

Table 1. Sample Characteristics, by Treatment Status

	Whole Sample (N=2941[b]) Mean	Treatment Group (N=1698) Mean	Control Group (N=1243) Mean	T-C Difference		Effect Sizes
				Difference	P-Value	
Race & Ethnicity						
American Indian	1.04%	0.83%	1.33%	-0.50%	0.19	-0.29
Asian	1.04%	1.02%	1.06%	-0.04%	0.913	-0.02
Black	27.57%	28.09%	26.88%	1.21%	0.467	0.04
Hispanic	7.97%	8.36%	7.45%	0.91%	0.367	0.08
Multi racial	3.17%	2.84%	3.62%	-0.78%	0.231	-0.15
White	59.21%	58.86%	59.67%	-0.80%	0.661	-0.02
Gender						
Male	40.74%	40.72%	40.77%	-0.05%	0.979	0.00
Age	15.33	15.32	15.35	-0.04	0.093	-0.07
Socioeconomic Background						
First Generation College	40.15%	39.24%	41.46%	-2.22%	0.266	-0.06
Free/Reduced Price Lunch Eligibility	49.01%	49.25%	48.68%	0.57%	0.764	0.01
Exceptionality						
Disabled/Impaired	2.18%	1.70%	2.87%	-1.17%	0.036*	-0.32
Gifted	8.25%	7.70%	9.04%	-1.34%	0.203	-0.11
Retained	3.63%	2.93%	4.56%	-1.64%	0.018*	-0.28
8th Grade Achievement						
Math - Z score	-0.01	-0.01	0.01	-0.02	0.612	-0.02
Reading - Z score	0.00	0.01	-0.02	0.03	0.461	0.03

Notes: [a] The proportions are weighted by students' probability of being selected into the ECHS. [b] This table includes only students with valid demographic data and thus differs slightly from the full analytic sample, which utilizes imputed covariates.
*Statistically significant at p<.05.

Table 2. Balance of the Matched Control and Treatment Students with Valid GPA

	Cumulative GPA through Grade 14		Cumulative GPA through Grade 15		Cumulative GPA through First Year in UNC System		Cumulative GPA through Second Year in UNC	
	Before Matching 732 Treat 408 Control	After Matching 730 Treat 406 Control	Before Matching 792 Treat 493 Control	After Matching 792 Treat 459 Control	Before Matching 797 Treat 495 Control	After Matching 795 Treat 491 Control	Before Matching 674 Treat 398 Control	After Matching 662 Treat 391 Control
Black	-0.03	0.01	-0.06	0.01	-0.07	0.02	-0.04	0.01
White	0.02	0.01	0.05	0.00	0.04	0.01	0.02	-0.01
Hispanic	-0.03	-0.04	-0.03	-0.02	0.00	-0.03	-0.04	-0.05
American Indian	-0.03	-0.05	0.01	-0.04	0.01	-0.03	0.07	-0.02
Multi-race	0.05	0.03	0.03	0.00	0.03	-0.02	0.03	0.03
Male	0.01	0.01	0.01	0.01	0.01	-0.01	-0.02	0.02
First Generation College Goer	-0.08	-0.03	-0.11	-0.03	-0.10	-0.05	-0.08	-0.02
Free/Reduced Price Lunch Eligible	-0.19	-0.01	-0.21	0.01	-0.22	0.00	-0.24	0.01
Gifted	0.10	0.03	0.09	0.02	0.09	-0.01	0.09	-0.01
Has Disability	0.12	0.01	0.11	0.01	0.12	-0.03	0.14	0.07
Age	-0.06	0.00	-0.09	0.00	-0.11	0.01	-0.10	-0.02
Retained in Grade 7 and/or Earlier	0.06	0.03	0.02	0.00	0.02	-0.02	0.02	0.03
Passed Algebra I in Grade 8	0.15	0.00	0.14	0.00	0.12	0.01	0.11	0.01
8th Grade Reading Score	0.13	0.00	0.13	0.00	0.14	0.00	0.10	0.00
8th Grade Math Score	0.17	-0.02	0.16	0.00	0.14	-0.01	0.11	-0.02
7th Grade Reading Score	0.18	0.04	0.16	0.00	0.16	0.00	0.14	0.02
7th Grade Math Score	0.24	0.00	0.23	0.00	0.21	-0.01	0.18	-0.01
Teacher Judgement of Reading Ability (8th Grade)	0.06	0.00	0.06	-0.01	0.07	0.00	0.07	0.00
Teacher Judgement of Math Ability (8th Grade)	0.03	-0.02	0.04	-0.02	0.06	-0.02	0.01	-0.03
8th Grade Absences	0.03	-0.01	0.03	-0.02	0.01	-0.02	0.01	-0.05
Performance Score for 8th grade school	0.10	-0.03	0.10	0.01	0.11	0.00	0.11	-0.04
District 4 Year Graduation Rate	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Number of Colleges within 8th Grade County	0.00	0.02	0.00	0.02	0.00	0.05	0.01	0.01

Notes: The standardized difference for a given measure is calculated by dividing the treatment-control difference by the pooled standard deviation of that measure. Grade seven and eight test scores are from End of Grade tests administered to all students in North Carolina.

Table 3: Impact of the Early College Model on Attainment of a Postsecondary Credential

	N	Adjusted Treatment Mean	Unadjusted Control Mean	Impact Estimate	Standard Error
Attainment of any Postsecondary credential	2968	37.0%	22.2%	14.8%**	2.7%
Attainment of Associate degree	2968	28.4	8.8	19.6**	3.1
Attainment of technical credential	2968	2.2	3.0	-0.8	0.7
Attainment of Bachelor's degree	2968	18.1	12.8	5.3**	1.3
Attainment of any postsecondary credential					
Underrepresented minority	1073	25.5	15.5	10.1**	2.9
Non-underrepresented minority	1875	43.9	25.9	18.1**	3.1
Differential impact				-8.0	4.3
First generation college-goers	1000	31.2	17.5	13.8**	3.6
Non-first generation college-goers	1488	40.8	26.8	14.0**	3.1
Differential impact				-0.3	4.7
Economically disadvantaged	1371	29.5	15.2	14.3**	4.0
Non-economically disadvantaged	1443	44.4	29.2	15.1**	2.7
Differential impact				-0.9	4.8
Underprepared students	640	17.3	9.8	7.5**	2.4
Prepared students	1967	44.7	28.1	16.6**	3.2
Differential impact				-9.1*	4.0

Notes: Adjusted treatment group mean is obtained by adding the impact estimate to the unadjusted control group mean. Statistical inference is conducted based on cluster-robust standard errors calculated according to the high school students were enrolled the longest. * significant at p≤.05; **significant at p≤.01.

Figure 2. Timing of Two-Year Degree Acquisition

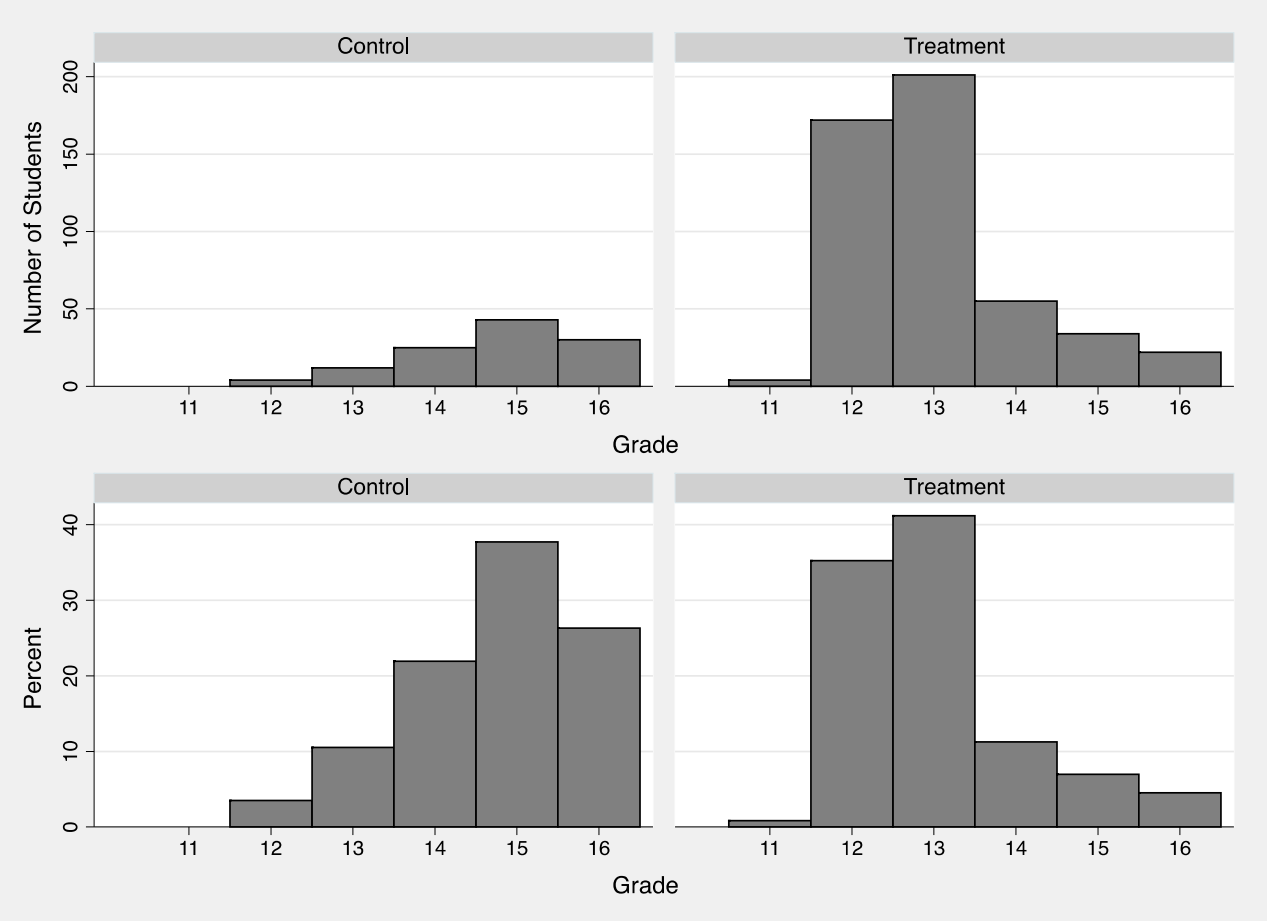

Figure 3. Timing of Four-Year Degree Acquisition

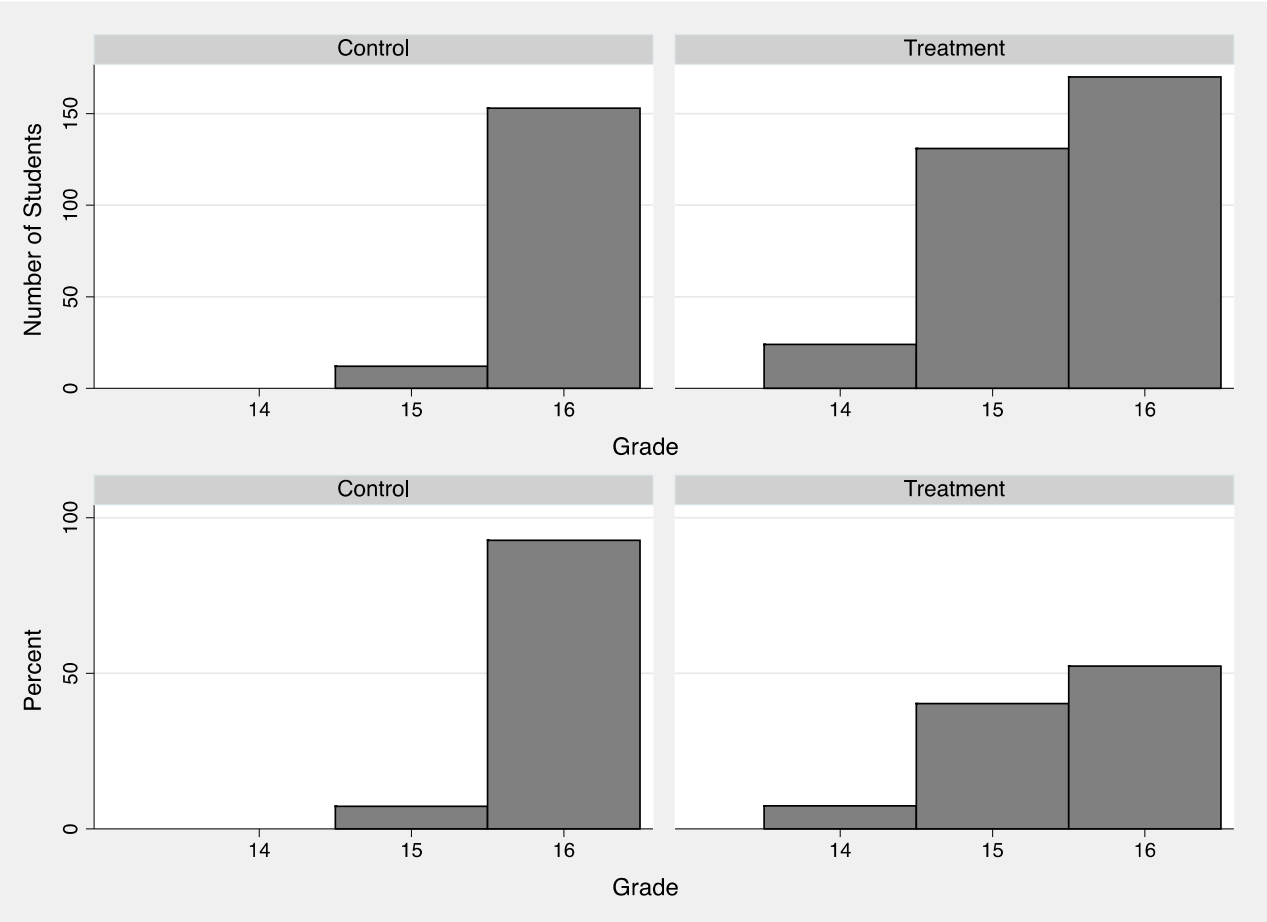

Table 4: Impact on GPA

	Adjusted Treatment Mean	N	Unadjusted Control Mean	N	Impact Estimate [Effect Size]	Standard Error
Cumulative GPA						
Through Grade 14	2.70	730	2.59	406	0.11* [ES: 0.13]	0.05
Through Grade 15	2.62	792	2.57	459	0.05 [ES: 0.06]	0.05
First Year	2.66	795	2.63	491	0.03 [ES: 0.03]	0.05
Second Year	2.76	662	2.75	391	0.01 [ES: 0.01]	0.04

Notes: Adjusted treatment group mean is obtained by adding the impact estimate to the unadjusted control group mean. Effect sizes for the impact estimates are presented in brackets and calculated by dividing the impact estimates by the pooled standard deviation. Statistical inference is conducted based on cluster-robust standard errors calculated according to the high school students were enrolled the longest. * indicates $p<0.05$.

Appendices:

Table A.1: Subgroup Effects on Two-Year and Four-Year Degree Acquisition

	N	Adjusted Treatment Mean	Unadjusted Control Mean	Impact Estimate	Standard Error
Attainment of two-year degree					
Underrepresented minority	1073	16.1%	3.7%	12.4%**	2.8%
Non-underrepresented minority	1875	35.6	11.6	24.0**	3.5
Differential impact				-11.5	4.5
First generation college-goers	1000	24.4	8.0	16.4**	3.5
Non-first generation college-goers	1488	31.4	9.5	21.9**	3.4
Differential impact				-5.5	4.8
Economically disadvantaged	1371	22.1	5.8	16.2**	3.5
Non-economically disadvantaged	1443	35.1	11.9	23.1**	3.7
Differential impact				-6.9	5.1
Underprepared students	640	9.6	4.4	5.2*	2.0
Prepared students	1967	36.4	10.5	25.9**	3.7
Differential impact				-20.7**	4.2
Attainment of four-year degree					
Underrepresented minority	1073	14.8	11.6	3.2	1.9
Non-underrepresented minority	1875	20.1	13.3	6.8**	1.5
Differential impact				-3.6	2.5
First generation college-goers	1000	13.2	8.6	4.6*	2.2
Non-first generation college-goers	1488	20.6	16.9	3.7*	1.8
Differential impact				0.9	2.9
Economically disadvantaged	1371	12.7	8.6	4.1*	1.7
Non-economically disadvantaged	1443	22.9	17.0	5.9**	1.9
Differential impact				-1.8	2.6
Underprepared students	640	8.0	4.6	3.3	1.8
Prepared students	1967	22.1	17.1	4.9*	1.7
Differential impact				1.6	2.5

Notes: ** $p<0.01$; * $p<0.05$.