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Longitudinal Findings From the Early College High School Initiative Impact Study

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This study is a randomized controlled trial that assessed the impact of Early College High Schools on students' high school graduation, college enrollment, and college degree attainment, as well as students' high school experiences using extant data and survey data. The study included 10 Early Colleges that enrolled students in Grades 9 to 12 in 2005 through 2011 and used a lottery for admissions, and 2,458 students who participated in those admission lotteries. The study time frame covered Grade 9 through 2 years post high school for all students and 4 years post high school for the oldest student cohort. It found that Early Colleges had positive impacts on college enrollment and college completion as well as students' high school experiences.

Keywords: *randomized controlled trial, Early Colleges, high school graduation, postsecondary outcomes*

The early college high school initiative (ECHSI), launched by the Bill & Melinda Gates Foundation in 2002, provided funds for the development of Early College High Schools (hereafter referred to as "ECs" or "EC"). ECs offer students who are traditionally underrepresented in postsecondary education the opportunity to pursue a high school diploma while earning college credits. The primary goal of the ECHSI is to increase students' access to a postsecondary credential. The ECHSI approach to achieving this goal is to improve underrepresented students' likelihood of earning a college degree by enrolling them in college courses while they are in high school and can receive support from high school staff.

There is substantial evidence that a postsecondary degree or credential prepares students for successful entry into the workforce. Bachelor's degree holders earn more over a lifetime than individuals with only a high school diploma (Carnevale, Rose, & Cheah, 2011), and college degree earners fared better in the recent American recession than adults who held only a high school diploma (Grusky, Bird, Rodriguez, & Wimer, 2013). Moreover, workforce projections consistently predict that the lion's share of future jobs will require a postsecondary degree (Carnevale, Smith, et al., 2011). Research also has consistently shown that students from disadvantaged families, such as minority students, students from low-income families, and students who are the first in their family to go to college, are less likely to earn a college degree than their more advantaged peers (National Center for Education

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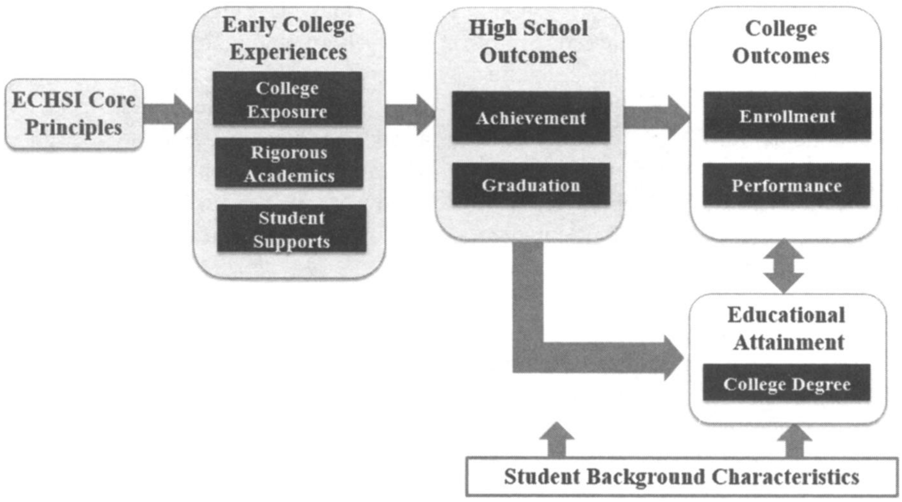

FIGURE 1. *ECHSI conceptual framework.*
Note. ECHSI = Early College High School Initiative.

Statistics [NCES], 2012a, 2012d). Therefore, postsecondary success, particularly success for underrepresented students, represents the most critical goal for the ECHSI.

Offering college courses to high school students is not unique to the ECHSI. In 2010 to 2011, 82% of public high schools offered dual credit courses that allowed students to earn both high school and college credits (Thomas, Marken, Gray, & Lewis, 2013), and approximately 53% of postsecondary institutions reported enrolling high school students in college courses either within or outside formal dual enrollment programs that enabled high school students to take college courses (Marken, Gray, & Lewis, 2013).

There are several core principles of the ECHSI that distinguish ECs from other dual enrollment programs. First, all ECs partner with colleges and universities to offer enrolled students an opportunity to earn an associate's degree or up to 2 years of college credits toward a bachelor's degree during high school at no or low cost to the students. The underlying assumption is that engaging underrepresented students in a rigorous high school curriculum tied to the incentive of earning college credits will motivate them and increase their access to additional postsecondary education and credentials after high school. Second, these EC opportunities are provided to all students, not only those who are academically advanced, and some ECs even focus on dropouts or students at risk of dropping out of high school.

Third, ECs provide a wide variety of academic and social supports—from personalized relationships to academic tutoring, advising, and help with study skills, time management, self-advocacy, other college "life skills," and college preparation (American Institutes for Research [AIR] & SRI International, 2008, 2009; Cassidy, Keating, & Young, 2010). ECs also provide supports in the formal transition to college, such as help in completing college applications and financial aid forms, which are important given that the complexity of the process is often a barrier to college attendance for academically qualified, low-income students (Bettinger, Long, Oreopoulos, & Sanbonmatsu, 2009; Hoxby & Avery, 2012). The combination of academic preparation and student supports in ECs is considered a best practice for helping students navigate the path to college (Tierney, Bailey, Constantine, Finkelstein, & Hurd, 2009).

Figure 1 illustrates the conceptual framework for the ECHSI. It shows that ECs are expected to provide college exposure, rigorous academics, and student supports. These high school features in turn are expected to promote improved high school outcomes, including high school achievement and graduation. Students' high school outcomes may lead them to engage in further college education or lead directly to college degree attainment if the students complete sufficient

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postsecondary credits while in high school. Finally, student background characteristics may affect student outcomes both during and after high school and may also moderate the EC impact on student outcomes.

Since 2002, more than 280 ECs have opened nationwide as part of the ECHSI (Webb & Gerwin, 2014). The ECHSI operated through 13 grantee organizations, or intermediaries, which received foundation funding to work with local partners—such as school districts, community organizations, tribes, high schools, community colleges, and universities—to open ECs. Since the ECHSI started, the call to improve high school education, college access, and college degree attainment has become louder. The number of ECs outside of the ECHSI has continued to increase across the country as the EC model is applied to high school turnaround, career and technical education, and other high school reform efforts.

During the past decade, a growing body of research evidence has emerged attesting to the promise of ECs as an effective way to promote postsecondary access and success. Most of the prior research, however, is descriptive in nature, and there has been only one other EC impact study that used a rigorous random assignment design (Edmunds, Bernstein, Unlu, Glennie, & Willse, 2012; Edmunds, Willse, Arshavsky, & Dallas, 2013). That study, however, included only schools from North Carolina, focused primarily on high school outcomes, and did not examine postsecondary outcomes beyond college enrollment. Employing a rigorous lottery-based random assignment design, the study reported in this article is based on ECs from multiple states and is the only impact study to date that examined the EC impact on both college enrollment and the ultimate postsecondary outcome of degree attainment. The study was guided by the following two research questions:

Research Question 1: Did treatment students have better outcomes (i.e., high school graduation, college enrollment, degree attainment, and high school experiences) than control students?

Research Question 2: Did the impact of ECs vary according to student background characteristics?

By tracking student outcomes for 2 years after high school graduation, we found that ECs had a positive impact on students' high school graduation, college enrollment, and degree completion, as well as their high school experiences. Before presenting study findings in further detail, a brief review of the relevant literature and a description of the study methods are in order.

Literature Review

Before describing the study design in detail, we briefly review the literature on college-level coursework in high school and research focused on ECs.

College-Level Coursework in High School

The primary goal of providing college experiences to high school students is to increase the likelihood that students will attain a postsecondary credential. Several studies have demonstrated positive associations between dual enrollment and student college outcomes. A correlational study conducted in two states (Karp, Calcagno, Hughes, Jeong, & Bailey, 2007), for example, found that students who had taken college classes during high school were more likely to earn high school degrees, enroll in college, enroll full-time, and persist in college than were students without college experience during high school. In addition, dual enrollment high school students were found to have higher college grade point averages (GPAs) and earn more college credits after high school graduation (Karp et al., 2007; Swanson, 2008). Using propensity score matching (PSM), a quasi-experimental study analyzed data from the National Educational Longitudinal Survey and found that dual enrollment participation increased the probability of attaining any postsecondary degree by 8% and a bachelor's degree by 7% (An, 2012). Another quasi-experimental study with PSM found that dual enrollment participation in Texas was positively associated with college attendance and completion (Struhl & Vargas, 2012).

Research has also demonstrated the positive relationships between dual enrollment and postsecondary outcomes for students who are traditionally underrepresented in college. Dual enrollment was found to be positively associated

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with college enrollment and GPA for low-income students and lower achieving students (Community College Research Center, 2012). A PSM study on the Concurrent Course Initiative (CCI) in California, a career-focused dual enrollment program targeting students traditionally underrepresented in college, found that CCI participants had higher rates of high school graduation, college enrollment, and college persistence; accumulated more college credits; and required less remediation than nonparticipants (Hughes, Rodriguez, Edwards, & Belfield, 2012; Rodriguez, Hughes, & Belfield, 2012).

Other programs, such as Advanced Placement (AP) and International Baccalaureate, provide high school students with exposure to college-level academic rigor to give them a head start in the transition to college. However, research on the impact of those programs on students' postsecondary outcomes is relatively limited and inconclusive (Foust, Hertberg-Davis, & Callahan, 2009; Klopfenstein & Thomas, 2009; May et al., 2013; Roderick, Nagoaka, Coca, & Moeller, 2009).

ECs: College Exposure With Student Supports

Most ECs partner with a college, are located on a college campus, and are new high schools. As of 2008, 65% of ECs had a 2-year college partner, 24% had a 4-year college or university partner, and 11% partnered with multiple colleges; 53% were located on a college campus; and 68% were new, start-up high schools (AIR & SRI International, 2009).

Findings from descriptive evaluation studies conducted during the first 8 years of the ECHSI indicate that ECs generally served a diverse student population, were implemented with fidelity, and had positive student outcomes (AIR & SRI International, 2008, 2009).

Academically, ECs had higher proficiency rates on state achievement tests and higher graduation rates than other schools in their feeder districts (AIR & SRI International, 2009). Most EC students took advantage of the opportunity to earn college credit, with 61% of the students and 73% of 12th graders reporting taking at least one college class (AIR & SRI International, 2009). On average, EC students graduated with a semester to a year of college credits, and 88% of graduates enrolled in college in the fall after graduation (AIR & SRI International, 2009).

As the number of ECs in operation long enough to graduate students has grown, studies have begun to examine college outcomes of EC students and they have consistently positive findings. Descriptive studies have found that EC students accrued substantial college credits and, often, an associate's degree in high school (Jobs for the Future, 2011; Webb & Mayka, 2011). Large majorities of EC students also enrolled in postsecondary education after high school graduation (Webb & Mayka, 2011). In addition, a longitudinal qualitative study of two ECs, which followed students from ninth grade through their second year of college, found positive social outcomes for EC students, including improvements in their ability to adapt to college demands and increases in the likelihood of them seeking out academic support, taking on leadership roles, and supporting their peers (Nakkula, 2011).

Employing an experimental design, a longitudinal study of the ECHSI's North Carolina Learn and Earn Initiative indicates that EC students were more likely to be "on track for college" than control group students; EC ninth-grade students were more likely than control students to take core college preparatory courses and succeed (Edmunds et al., 2012). The study also found that EC students had higher attendance rates, lower suspension rates, and higher levels of engagement than control students (Edmunds et al., 2013).

Over a decade of research on ECs has produced promising findings. Most of these studies, however, are descriptive and do not warrant causal conclusions about the impact of ECs. The only prior experimental study of ECs (Edmunds et al., 2012) included only schools in North Carolina and focused primarily on high school outcomes. Relying on a rigorous experimental design and ECs from multiple states, the study reported in this article fills that gap and adds to the growing body of research on dual enrollment and accelerated learning opportunities for high school students.

Method

We assessed the impact of ECs using a lottery-based randomized experiment, taking advantage of the fact that some of the ECs used lotteries in

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TABLE 1
Number of ECs and Students in Study Sample, by Cohort Year

	2005–2006	2006–2007	2007–2008	Total
ECs	3	7	7	10
Treatment students	133	431	480	1,044
Control students	343	551	520	1,414

Note. ECs = Early College High Schools.

their admission processes. For this study, we defined "treatment students" as lottery applicants who were offered enrollment either through the initial lottery or from a randomized waitlist prior to the first day of school and control students as lottery applicants who were not offered enrollment. Given the lottery-based random assignment, we expect treatment students and control students to have similar characteristics, both observed and unobserved, prior to the lottery. Thus, by comparing the outcomes of these two groups of students, we can draw valid causal conclusions about the impact of ECs.

A key design feature of this study is that it is retrospective. We sought sites that conducted lotteries long enough in the past that students who participated in the lotteries would have had the opportunity to graduate from high school and enter postsecondary education by the time data collection concluded. The retrospective feature of the design made it possible to estimate the impact on postsecondary outcomes within a reasonably short study time frame.

Sample

To be eligible for the retrospective impact study, an EC had to meet the following criteria for at least 1 of 3 school years (2005–2006 through 2007–2008): (a) enrolled students in Grades 9 to 12, (b) had high school graduates, (c) were oversubscribed and used lotteries in their admission processes for incoming ninth graders, and (d) retained the lottery records. We restricted the study sample to all ECs that were open by fall 2007 to ensure that students in the study would have had the opportunity to complete at least 2 years of college by the end of data collection for the study (i.e., 2012–2013). If students progressed at the expected pace, Cohort 1 students who entered ninth grade in 2005–2006 would graduate in 2008–2009 and could have completed 4 years of college within the study period. Similarly, Cohort 2 students could have completed 3 years of college, and Cohort 3 students could have completed 2 years of college.

Of the 154 ECs open nationwide by fall 2007, about two thirds were not eligible for the study because they were undersubscribed; of the remaining ECs, 10 met the criteria for inclusion in the study.[1] All of the 10 ECs were newly created schools, some of which had multiple participating cohorts and met the criteria for more than 1 school year. Some ECs also conducted multiple lotteries in a given year, such as separate lotteries for applicants from each feeder school or district. Our full study sample includes 17 lotteries across 10 sites and three cohorts, with 1,044 treatment and 1,414 control students (2,458 students in total and an overall admission rate of 42.5%; see Table 1). Not all students, however, complied with their lottery-based assignment. Based on records of enrollment during the first year of high school, 22% of the treatment students did not attend an EC (i.e., "no-shows") and 2% of the control students ended up attending an EC (i.e., "crossovers") across the 10 study sites.[2]

It is important to note that, given the sample selection criteria necessary for the retrospective study design, the 10 ECs that met those criteria were a unique set of oversubscribed ECs and not representative of the population of ECs in the nation. The structure of the ECs in the study sample mirrored that of the ECs in the national population: All study ECs were opened as new schools on a college campus, college courses were taught by a college instructor, seven of the 10 ECs partnered with a 2-year college, two partnered with a 4-year university, and one had both a 2-year and a 4-year partners. The students in study ECs,

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TABLE 2
Background Characteristics of Treatment and Control Students and Group Differences

Characteristics	Treatment group mean	Control group mean	Difference	*n*
Female	51.8%	52.9%	−1.1%	2,456
Minority	52.5%	53.7%	−1.2%	2,449
First-generation college going	21.6%	19.9%	1.7%	1,251
Low income	47.3%	45.2%	2.1%	2,258
Prior achievement in ELA (standardized test score)	0.28	0.17	0.11**	2,065
Prior achievement in math (standardized test score)	0.22	0.22	0.00	2,011

Note. All data were from administrative data sources except for first-generation status, which came from a student survey. Treatment group means are unadjusted means, and control group means were computed by subtracting the estimated group difference from the unadjusted treatment group means. Prior achievement scores were standardized using statewide assessment means and standard deviations. ELA = English language arts.
*$p < .05$. **$p < .01$. ***$p < .001$.

however, were somewhat less disadvantaged than students in the population of ECs. Nationally, in 2008, 67% of EC students were minority and 59% were low income (AIR & SRI International, 2009). In comparison, 53% of the EC students in the study sample were minority and 47% were from low-income families (see Table 2). Moreover, students who chose to participate in an EC admission lottery might differ from those who did not in other characteristics (e.g., motivation).

Thus, the external validity of this study is limited. However, this study allows us to draw causal conclusions through a rigorous design with strong internal validity. By taking advantage of a naturally occurring lottery-based experiment, we were able to observe the counterfactual—that is, the outcome that lottery winners would have experienced had they not been randomly selected to attend the EC.

To verify whether the retrospective lotteries resulted in equivalent study groups as we had expected, we tested for group baseline equivalence on a variety of student background characteristics, including gender, minority status (i.e., non-White), eligibility for free or reduced-price lunch, first-generation status, and English language arts (ELA) and mathematics test scores prior to high school. We found that the two groups were not significantly different in any characteristic except in prior ELA scores, where treatment students had higher test scores (see Table 2). However, the difference between the two groups in prior math scores (which was not significant) was in the opposite direction, suggesting that the single significant group baseline difference was likely due to chance.

Data

We collected data from multiple sources using names and birthdays of both treatment and control students from the lottery records. We gathered administrative data from ECs, districts, and state departments of education on student characteristics and high school outcomes. The specific data sources for these variables differed by site, and in some sites, we were able to obtain data for the same measure from multiple sources. Data for postsecondary enrollment and degree attainment came from the National Student Clearinghouse (NSC; 2015), which collects data from higher education institutions across the country and covers more than 98% of all student enrollments in public and private colleges and universities. For all lotteries, we used data from the same source(s) in our analyses for both treatment and control students within the same lottery.

We requested NSC data for each student in our study sample. We assumed that students for whom the NSC could not find matching records did not attend college or attain a postsecondary degree; thus, our estimates of postsecondary outcomes are conservative. Students may be missing from the NSC for one of the following reasons: They attended a college that did not

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provide data to NSC, they did not allow NSC to share their individual record data, or their name or birthdate in our records did not match that in the NSC. However, we have no reason to expect NSC data to be differentially missing for treatment and control students.

In addition to collecting administrative records and NSC data for the full study sample, we also collected data on students' high school experiences through a student survey. The survey was administered in 2012—after their expected high school graduation—to 1,416 randomly selected students in the two oldest cohorts. Students from Cohort 1 were not surveyed because we were not confident in students' ability to recall their high school experiences multiple years after leaving high school. The survey response rate was 94% for EC students and 88% for control students. Non-response-adjusted survey weights were applied to all analyses of survey data.[3]

Measures

Consistent with the goals of the ECHSI and the foundation's college-readiness and postsecondary success strategies (Bill & Melinda Gates Foundation, 2009), the primary outcomes for this study include whether students graduated from high school, enrolled in college, and earned a college certificate or degree. For high school graduation, we measured the percentage of students earning a high school diploma or general equivalency diploma (GED). For college enrollment and college degree attainment, we examined whether students enrolled in college or earned any degree by fall 2013 (i.e., the end of study data collection), including either during or after high school. By college degree, we mean any postsecondary credential, including certificates, associate's degrees, or bachelor's degrees.

In addition to the primary outcomes, we differentiated between college enrollment and degree completion while in high school and after high school to provide context about the timing of the EC impact on students' college enrollment and degree attainment, which allowed us to understand how the EC impact may have changed over time.

Relying on survey data, we also measured several key aspects of students' experiences during high school that were related to students' preparation for and experience with college. To measure college exposure, we examined students' college course-taking and credit accumulation as well as their AP course-taking and exam passage in high school. To measure student supports, we examined the college-going culture in the school, instructor support, and whether students had access to general information about college. The measure for college-going culture is a 1 to 4 scale based on three survey items asking about the extent to which students agreed that teachers, principals, and students in their high school expected students to go to college (1 = *strongly disagree* and 4 = *strongly agree*; α reliability = .80). The measure for instructor support is a 1 to 4 scale based on six items asking about the extent to which students agreed that their high school teachers cared whether students came to school, praised students for their effort, helped students, listened to students, encouraged students, and cared about students (1 = *strongly disagree* and 4 = *strongly agree*; α reliability = .88).

Across all analyses, we included the following student background characteristics as covariates: gender, race and ethnicity, first-generation college-going status, low-income status, and academic achievement prior to high school.

Analytic Approach

Our primary impact model used intent-to-treat (ITT) analysis, which estimates the impact of being offered admission to an EC through a lottery, regardless of whether the student actually enrolled in the EC. To estimate the overall ITT effects across lotteries, we constructed a two-level model that takes into account the clustering of students within lotteries. The treatment indicator was group-mean centered at the student level to make sure the comparisons of EC students and control students were made *within* rather than across lotteries and thus produced unbiased estimates (Enders & Tofighi, 2007; Raudenbush, 1989). We modeled the intercept as a random effect to take into account the clustering of student outcomes within lotteries. We modeled the treatment effect as fixed at the lottery level because the number of lotteries in the study was too small to generate stable estimates of the variation in treatment effects across lotteries.

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Compared with a random-effects model with both random intercept and random treatment slope at the lottery level, the fixed-effects model is associated with greater statistical power and does not require the assumption that the lotteries in the study sample were representative of a larger population of lotteries. The fixed-effects model, however, does not allow us to generalize study findings to EC admission lotteries beyond those in the study sample or examine the variation in EC impact across lotteries. An alternative specification of the fixed-effects model is a student-level regression with lottery fixed effects and treatment-by-lottery interactions. Such a model, however, suffers from the "quasi-complete separation" problem for binary outcomes in our study, because in some lotteries, 100% of the treatment students and/or 100% of the control students experienced the outcome. Thus, lottery-specific treatment effects cannot be estimated.

Below is the specification of the fixed-effects hierarchical generalized linear model (HGLM) that we used to assess the treatment effect on a binary outcome (graduation from high school in this example):

Level 1 Model (Student Level)

$$\log\left[\frac{\phi_{ij}}{\left(1-\phi_{ij}\right)}\right] = \beta_{0j} + \beta_{1j}\mathrm{EC}_{ij} + \beta_{2j}\mathbf{X}_{ij} + \sum_{m=2}^{m}\left(\beta_{3mj}\mathrm{SUBLOT}_{mij}\right) + r_{ij},$$

where ϕ_{ij} is the probability of graduating from high school for student i in lottery j; EC_{ij} is a dummy indicator for treatment status (coded 1 if the student won the lottery and 0 otherwise, centered on lottery mean); $\mathbf{X}_{ij}$ is a vector of student characteristics, grand mean centered; and SUBLOT_{mij} is a set of effect-coded indicators for the m sublotteries within a lottery with multiple sublotteries.[4]

Level 2 Model (Lottery Level)

$$\beta_{0j} = \gamma_{00} + u_{0j},$$

$$\beta_{1j} = \gamma_{10},$$

$$\beta_{2j} = \gamma_{20},$$

$$\beta_{3mj} = \gamma_{3m0}.$$

The estimate of primary interest from the model is γ_{10} at the lottery level, which represents a precision-weighted overall treatment effect across all lotteries in the study sample, with larger weights for lotteries with more students. We computed the effect sizes for binary outcomes by dividing the logged odds ratio by 1.65 (i.e., the Cox index), as recommended by the What Works Clearinghouse.

To answer the second research question about potential differential effects of ECs on students with different background characteristics, we ran a second set of models that incorporate an interaction between treatment status and a given student characteristic into the student-level model. The lottery-level estimate for the interaction term captures the average difference in the treatment effect on high school graduation between student subgroups (e.g., female and male) across all lotteries in the study sample. We explored whether the effects of being admitted to an EC differed significantly by gender, minority status, first-generation college-going status, low-income status, or level of prior mathematics and ELA achievement.[5] We conducted all of the differential effect analyses for the three key outcomes: high school graduation, college enrollment, and college degree attainment.

We used multiple imputation to address the potential selection bias caused by missing covariates. The model for multiple imputation included all background and outcome variables available from both the extant data and the student survey data. We generated 10 imputed data sets, conducted all analyses using each imputed data set separately, and then combined estimates across the 10 data sets, taking into account the uncertainty in imputed values both within and across the imputed data sets. Our primary impact analyses used imputed covariate values and excluded students with missing outcomes.

Findings

This section describes the impact findings for the three key outcomes—high school graduation, college enrollment, and college degree attainment—as well as high school experiences. We examined college enrollment and degree attainment outcomes in three ways: outcomes at any point in the study period; cumulative outcomes

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by Year 4, Year 5, and Year 6; and outcomes after high school (after Year 4). Year 4 reflects the period when students would traditionally be in their final year of high school. For students on a traditional trajectory, Year 5 is the year immediately following high school graduation. Year 6 (2 years after high school graduation in a typical time frame) is the last year for which we have data for all students in the study. Given that the study time frame does not extend to Year 8 or beyond for all students, it is not possible to definitively capture college degree attainment. Thus, we analyzed college outcomes at different points in time to parse out the timing of the effects, allowing us to examine whether the EC impact was concentrated in the high school years or whether the impact persisted after high school.

In addition to whether and when students enrolled in college, we also examined where they enrolled. More than 75% of ECs partner with 2-year colleges (AIR & SRI International, 2009), which has led to the criticism that ECs may funnel students primarily into 2-year colleges and away from educational pathways that would lead to a bachelor's degree. To address this critique, we examined whether treatment students were more likely to enroll in 2-year and 4-year institutions by the end of Year 4 (before students are expected to graduate from high school) and by the end of Year 6 (when students on a traditional trajectory could have attended college for up to 2 years).

High School Graduation

Being admitted to an EC did not have a statistically significant impact on the likelihood of graduating from high school (88.0% for EC students and 86.1% for control students; see Table 3). The majority of students in both study groups graduated from high school, and the graduation rates of both groups compared favorably with the national on-time graduation rate of 75.5% reported for the 2008–2009 academic year, the year in which our study's oldest cohort was expected to graduate (NCES, 2013a).

The sum of the percentage of students earning associate's degrees and bachelor's degrees exceeds the overall percentage of students earning any degree because many of the students who earned a bachelor's degree had already earned an associate's degree.

We also examined whether ECs had differential effects on high school graduation for students with different background characteristics (Research Question 2). As the first panel in Table 4 shows, there were no significant differences in the impact of ECs on high school graduation by any of the student characteristics examined.

College Enrollment

Because ECs build in college course-taking as part of their design, we should expect treatment students to enroll in college courses at higher rates during high school than control students. However, treatment and control students alike had the opportunity to enroll in college following high school graduation. Therefore, we examined whether students in the study ever enrolled in college during the study period (by the end of the 2012–2013 academic year). Students in the oldest cohort had a longer period of time to enroll in and graduate from college compared with students in the younger cohorts. Our models account for this difference because students were only compared within each cohort.

The analysis of college enrollment was based on NSC data, which record student enrollment by academic term (e.g., semester, quarter). We counted students as enrolling in college if they had any enrollment record, meaning that they enrolled for at least one term. Our analysis showed that being admitted to an EC had a statistically significant positive impact on college enrollment: 80.9% of treatment students had at least one record of college enrollment in the NSC, roughly 9 percentage points higher than the 72.2% college enrollment rate for control students (see Table 3). This impact did not differ significantly for students with different background characteristics (see Table 4).

To cast further light on the impact of ECs on college attendance, we conducted additional analyses examining college enrollment by the end of students' fourth, fifth, and sixth years after starting ninth grade. We found that ECs had a significant impact on college enrollment rates by the end of Year 4—63.5% of treatment students relative to 24.3% of control students (see Table 3). Although the goal of the ECs is for all students to take and complete college courses while in high school, our findings suggest that the ECs did not

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TABLE 3

ITT Estimates of the Overall EC Impact on High School and College Binary Outcomes

Outcome	Effect in logits	Odds ratio	*SE*	Treatment group mean (%)	Control group mean (%)	Effect size	*p* value
High school graduation	0.17	1.19	.15	88.0	86.1	0.105	.2579
College enrollment	0.49	1.63	.12	80.9	72.2	0.298	<.0001
College enrollment by Year 4	1.69	5.41	.11	63.5	24.3	1.023	<.0001
College enrollment by Year 5	0.54	1.72	.11	77.9	67.2	0.328	<.0001
College enrollment by Year 6	0.55	1.73	.11	80.7	70.7	0.331	<.0001
2-year college enrollment	0.84	2.33	.11	60.8	40.0	0.512	<.0001
2-year college enrollment by Year 4	1.92	6.82	.13	48.3	12.0	1.164	<.0001
2-year college enrollment by Year 5	1.05	2.85	.11	55.8	30.7	0.635	<.0001
2-year college enrollment by Year 6	0.90	2.46	.11	60.0	37.8	0.546	<.0001
4-year college enrollment	0.17	1.19	.10	54.4	50.1	0.105	.0965
4-year college enrollment by Year 4	1.07	2.92	.16	25.2	10.4	0.649	<.0001
4-year college enrollment by Year 5	0.21	1.23	.11	49.1	44.0	0.126	.0526
4-year college enrollment by Year 6	0.28	1.32	.10	53.3	46.3	0.169	.0081
Earned any postsecondary degree	1.90	6.71	.17	24.9	4.7	1.153	<.0001
Earned any certificate	0.12	1.13	.42	1.3	1.2	0.076	.7656
Earned any AA	2.50	12.14	.21	22.7	2.4	1.513	<.0001
Earned any BA	1.34	3.80	.33	4.5	1.2	0.81	<.0001
Any degree by Year 4	3.57	35.37	.33	20.9	0.7	2.161	<.0001
Any degree by Year 5	3.06	21.38	.26	22.4	1.3	1.856	<.0001
Any degree by Year 6	2.69	14.66	.22	23.7	2.1	1.627	<.0001
College enrollment after Year 4	0.13	1.14	.11	73.1	70.5	0.078	.2292
2-year college enrollment after Year 4	−0.06	0.94	.10	35.7	37.2	−0.038	.5302
4-year college enrollment after Year 4	0.14	1.16	.10	52.4	48.8	0.088	.1607
Any degree after Year 4	0.54	1.71	.21	7.8	4.7	0.325	.0091
AA after Year 4	0.27	1.31	.32	2.6	2.0	0.166	.3884

Note. $n = 2{,}207$ (976 treatment, 1,231 control) for high school graduation; and $n = 2{,}458$ (1,044 treatment, 1,414 control) for all other outcomes. The treatment group probabilities are unadjusted probabilities; the control group probabilities were computed based on the unadjusted treatment group probabilities and estimated EC effects. To compute the adjusted control group probability in percent, we first converted the unadjusted treatment group probability from percent to logit, and then computed the control group probability in logit by subtracting the estimated EC effect in logit from the treatment group probability in logit. We then converted the control group probability in logit to probability in percent. ITT = intent-to-treat; EC = Early College High Schools; AA = associate's degree; BA = bachelor's degree.

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TABLE 4

Differential EC Impact on High School Graduation, Ever Enrolled in College, and Ever Earned Any Postsecondary Degree, by Student Background Characteristics

	Probability ($X = 1$)				Probability ($X = 0$)				Differential effect		
Student characteristic	Treatment group mean (%)	Control group mean (%)	Difference (%)	*n*	Treatment group mean (%)	Control group mean (%)	Difference (%)	*n*	Odds ratio	Difference in effect (%)	*p* value
High school graduation											
Female	84.9	83.1	1.8	1,264	87.1	77.8	9.4	1,194	0.6	−7.5	.0764
Minority	87.4	81.8	5.6	1,600	89.0	82.5	6.5	859	0.9	−0.9	.7523
Low income	82.6	73.7	8.9	1,268	88.8	86.6	2.1	1,198	1.4	6.7	.2759
First generation	80.0	77.8	2.3	958	88.6	81.7	6.9	1,508	0.7	−4.6	.1984
Enrolled in college											
Female	82.1	77.4	4.7	1,264	79.7	66.5	13.3	1,194	0.7	−8.6	.0839
Minority	81.0	74.3	6.7	965	84.8	74.0	10.7	856	0.8	−4.0	.2842
Low income	76.3	66.7	9.6	1,266	85.7	76.4	9.3	1,130	0.9	0.3	.5967
First generation	74.8	70.2	4.6	958	83.6	73.2	10.4	1,508	0.7	−5.8	.2466
Earned any postsecondary degree											
Female	27.0	5.2	21.8	1,264	22.7	4.2	18.4	1,194	1	3.4	.9696
Minority	29.4	3.0	26.4	965	25.8	6.5	19.2	856	2.7	7.2	.0059
Low income	22.1	2.6	19.5	1,266	27.6	7.2	20.3	1,130	2.2	−0.8	.0245
First generation	23.7	4.0	19.8	958	25.3	5.0	20.4	1,508	1.2	−0.6	.7463

Note. $X = 1$ for female, minority, low income, or first generation; $X = 0$ for male, nonminority, not low income, or not first generation. The treatment group probabilities within a given student subgroup are unadjusted probabilities; the control group probabilities were computed based on the unadjusted treatment group probabilities and estimated EC effects within the subgroup. The values in the Difference columns may not match the difference between the treatment and control group means because of rounding. EC = Early College High Schools.

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meet this goal, as over one third of treatment students did not enroll in college while in high school (see Table 3). This result is consistent with previous research that found that about one third of upper-grade high school students were not enrolled in college classes (AIR & SRI International, 2008, 2009). Explanations include that some students in our treatment group never attended an EC (i.e., "no-shows"), some students left the EC before high school graduation, and the NSC provides conservative estimates for college enrollment. Still, treatment students began accessing college earlier and enrolled in college during high school at significantly higher rates than their control peers.

The treatment impact on college enrollment persisted after high school. By the end of Year 5, 77.9% of treatment students and 67.2% of control students had enrolled in college (see Table 3). By the end of Year 6, 80.7% of treatment and 70.7% of control students had done the same. Between Year 4 and Year 6, the gap between the groups narrowed from 39.2 to 10.0 percentage points. Nevertheless, the difference in college enrollment rates between the two groups remained statistically significant.

In regard to where treatment and control students enrolled, our results indicate that being admitted to an EC had a statistically significant positive impact on attending a 2-year college. The percentage of treatment students who attended 2-year colleges during the study period (60.8%) was significantly higher than the percentage for control students (40.0%) (see Table 3). This difference might be expected, particularly during the high school years, because most ECs partnered with local 2-year institutions. Indeed, a gap of more than 36 percentage points existed between the two groups by the end of Year 4 (48.3% for treatment students and 12.0% for control students). By the end of Year 6, the gap shrank to 22 percentage points (60.0% for treatment students and 37.8% for control students) but remained statistically significant.

We also examined the trend for enrollment at 4-year colleges. If ECs funneled students primarily toward attending 2-year institutions, we might see lower rates of 4-year college attendance for EC students than for control students. In fact, being admitted to an EC did not have a significant impact on attending a 4-year college during the study period (see Table 3). Exploring enrollment rates over time shed light on potential explanations for this finding.

Although the overall 4-year college enrollment rates for treatment students and control students did not differ, their enrollment patterns differed. As Table 3 shows, the two groups differed significantly in 4-year college enrollment rates by Year 4 (by 14.8 percentage points). By Year 5, the gap narrowed and was no longer significant. However, by Year 6, the significant gap favoring treatment students reemerged (by 7.0 percentage points). Our data do not enable us to determine the reason for this trend. One possibility is that treatment students continued to attend 2-year colleges to complete an associate's degree and then progressed to 4-year colleges. If this were the case, the increase in the gap between the groups by Year 6 could reflect treatment students' transition to 4-year institutions.

The findings for 4-year college enrollments are particularly important because prior research has found that disadvantaged students were less likely to enroll in a 4-year institution, even if academically prepared. For example, Horn and Nuñez (2000) found that even after controlling for academic qualifications, first-generation students were less likely than their peers to enroll in a 4-year college. Our findings indicate that ECs were *not* guiding students away from postsecondary paths that would lead to bachelor's degrees.

College Degree Attainment

Although college enrollment is a key indicator of students' likelihood of attaining a postsecondary credential or degree, the fundamental question for the study is whether EC students were more likely to earn a postsecondary degree. Our results indicate that being admitted to an EC had a statistically significant positive impact on degree attainment. By the end of the 2012–2013 academic year, 24.9% of treatment students earned postsecondary degrees compared with 4.7% of control students (see Table 3).

The significant positive treatment effect held for associate's and bachelor's degrees but not for

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certificates. Almost one quarter (22.7%) of treatment students earned an associate's degree compared with 2.4% of control students (see Table 3). Bachelor's degree attainment understandably occurred at lower rates because no students in our study had an opportunity to attend college for the 4 years after high school that a bachelor's degree traditionally requires. Nevertheless, a significant difference between the study groups existed, with 4.5% of treatment students earning a bachelor's degree and only 1.2% of control students doing the same.

Certificate attainment for the two groups of students was similar, with few students in either group earning a certificate (1.3% of treatment students and 1.2% of control students). Most certificate programs require 2 years of coursework or less to complete, meaning that students in the study should have had the opportunity to complete a certificate program if that was their desired path. The low rate of certificate attainment for both groups suggests that students in the study who pursued a college education did so primarily by enrolling in degree-granting programs.

In addition to the overall effect of ECs on degree attainment, we examined whether the EC effect differed by student background characteristics. Although the effect of ECs on degree attainment was similar for males and females and for first-generation students and non-first-generation students, it differed significantly by other student characteristics as summarized below (also see Table 4):

- *Race:* The EC impact on college degree attainment was significantly stronger for minority students than for White students. Among minority students, treatment students were nearly 10 times as likely to obtain a college degree as control students (29.4% vs. 3.0%). Among White students, treatment students were approximately 4 times as likely to obtain a college degree as control students (25.8% vs. 6.5%).
- *Income:* The EC impact on college degree attainment was significantly stronger for low-income students. Specifically, low-income treatment students were approximately 8.5 times as likely as low-income control students to obtain a college degree (22.1% vs. 2.6%). In contrast, higher income treatment students were approximately 4 times as likely to obtain a degree as higher income control students (27.6% vs. 7.2%).
- *Prior achievement:* The impact of EC on college degree attainment was significantly stronger for students who entered high school with higher mathematics and ELA scores than for students with lower scores.[6]

We also examined college degree attainment by Year 4, Year 5, and Year 6. The data suggest that the overwhelming majority of treatment students who earned a college degree did so during high school. Of all treatment students, 20.9% received at least one degree by Year 4, 22.4% by Year 5, and 23.7% by Year 6 (see Table 3). In contrast, very few control students earned a college degree by the same point in time (0.7%, 1.3%, and 2.1% for the 3 years, respectively).

College After High School

In addition to the analyses described above, we explored post–high school outcomes to better understand the impact of ECs after students leave the high school environment. For this set of analyses, "after high school" indicates the period of time after the end of Year 4. For students following a traditional trajectory, these post–Year 4 outcomes correspond to the years after high school, but some study students participated in 5-year high school programs and would still be in high school during Year 5.

We first examined college enrollment rates after the end of Year 4 and found no statistically significant difference between treatment students and control students in the rate of enrollment at any institution, 2-year institutions, or 4-year institutions (see Table 3).[7] In other words, the impact of ECs on college enrollment occurred during high school rather than after high school. Thus, despite the fact that ECs partnered primarily with 2-year colleges, EC students did not appear to enroll in 2-year colleges at the expense of 4-year college enrollment.

We also examined degree attainment rates after high school. Overall, treatment students had

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TABLE 5

ITT Estimates of the Overall EC Impact on High School Experiences, Binary Outcomes

Outcome	Total *n*	Treatment *n*	Control *n*	Effect in logits	Odds ratio	*SE*	Treatment group mean (%)	Control group mean (%)	Effect size	*p* value
Earned any college credit in high school	1,265	707	558	2.08	8.04	.15	66.6	19.9	1.264	<.001
Earned 1 year of college credit in high school	1,265	707	558	2.92	18.61	.19	49.5	5.0	1.772	<.001
Took at least 1 AP course	1,215	656	559	−1.49	0.23	.15	22.1	55.7	−0.903	<.001
Passed at least 1 AP exam	1,215	656	559	−1.67	0.19	.19	8.8	33.9	−1.013	<.001
Access to general college information in school	1,294	724	570	0.27	1.31	.14	83.6	79.5	0.165	.0601

Note. The treatment group means are unadjusted probabilities; the control group probabilities were computed based on the unadjusted treatment group probabilities and estimated EC effects. ITT = intent-to-treat; EC = Early College High Schools; AP = Advanced Placement.

higher rates of degree attainment after Year 4: 7.8% of treatment students earned a postsecondary degree or credential as compared with 4.7% of control students (see Table 3). Specifically, EC students (4.5%) were more likely to earn a bachelor's degree after Year 4 than were control students (1.2%). However, the percentages of students earning associate's degrees after Year 4 in the two groups were statistically indistinguishable (2.6% of treatment students and 2.0% of control students).

High School Experiences

We examined two components of students' high school experiences—students' exposure to college in high school and supports offered by high schools—to explore some of the mechanisms through which ECs may impact student outcomes. These measures came from the student survey administered to students in fall 2012 (i.e., Year 5 or Year 6 after entering high school for survey respondents in Cohorts 3 and 2, respectively).

College Credit and AP Exams. College credit accrual during high school puts students on an accelerated path to postsecondary degree attainment. Our study found that ECs had a significant positive impact on earning college credits in high school, with 66.6% of treatment students and 19.9% of control students earning any college credit (see Table 5). In addition, treatment students were significantly more likely to meet the ECHSI's goal of earning at least 1 year of college credit: Almost half (49.5%) of treatment students earned at least 1 year of college credit while in high school compared with only 5.0% of control students.

Control students may not have had access to college courses, but they may have had access to AP coursework and, thus, the opportunity to earn college credit by passing AP exams. As Table 5 shows, control students had higher rates of both AP course-taking and exam passage. Over half (55.7%) of control students took at least one AP course in high school, whereas less than a quarter (22.1%) of treatment students did so. Approximately one third of control students passed at least one AP exam, relative to 8.8% of treatment students.[8]

Although control students enrolled in AP courses and passed AP exams at significantly higher rates than treatment students, AP course-taking did not lead to substantial college credit accumulation for either group. On average, treatment and control students passed fewer than one AP exam (.23 AP exams passed for treatment students and .70 for control students)[9]; thus, AP coursework did not meaningfully accelerate control students' path toward postsecondary degree attainment. In contrast, treatment students earned a substantial amount of college credit in high school, giving them a head start toward postsecondary degree attainment.

Student Supports. As demonstrated in prior research, supports are often required in addition to offering students access to dual enrollment

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TABLE 6

ITT Estimates of the Overall EC Impact on High School Experiences, Continuous Outcomes

Outcome	Coefficient	*SE*	Treatment group mean	Control group mean	Effect size	*p* value
College-going culture (scale)	.18	.03	3.5	3.3	.3207	<.0001
Instructor support (scale)	.18	.03	3.4	3.2	.3166	<.0001

Note. n = 1,293 (n = 723 treatment, n = 570 control). The treatment group means are unadjusted means; the control group means were computed based on the unadjusted treatment group means and estimated EC effects. ITT = intent-to-treat; EC = Early College High Schools.

courses to help students adjust to the different norms and expectations at the college level (Cassidy et al., 2010). This section explores whether treatment students received greater supports from their schools to prepare them for college than their control peers.

First, ECs aim to establish an environment where all students feel they are expected to go to college. As Table 6 shows, treatment students reported significantly stronger college-going cultures at their high schools than control students. The average score for treatment students was 3.5 compared with 3.3 for control students on the 1 to 4 college-going culture scale. This difference corresponds to an effect size of .32, which was computed as standardized mean difference based on the pooled standard deviation of the outcome across treatment and control students.

Second, ECs aim to support students in meeting these expectations of college attendance. One way ECs do this is by talking about college and providing students with information about college. Our survey asked students whether they had at least one "very helpful" resource at their high school to provide them with general information about college. As Table 5 shows, about 80% of students in both groups reported having at least one "very helpful" resource to learn about college—83.6% of treatment students as compared with 79.5% of control students, a difference that was not statistically significant.[10]

Third, ECs aim to support students academically and socially. The student survey measured instructor support as an indicator of ECs' emphasis on personalization and instructor–student relationships. As Table 6 shows, both groups agreed that their high school instructors were supportive, but the level of support was significantly higher for treatment students. Treatment students had a mean score of 3.4, and control students had a mean score of 3.2 on the 1 to 4 instructor support scale (effect size = .32).

Sensitivity Analyses

We performed several types of sensitivity analyses to assess the overall EC impacts on the three primary outcomes (i.e., high school graduation, college enrollment, and any postsecondary degree). First, we conducted impact analyses that excluded particular sites because of a high no-show rate, a high crossover rate, or significant group difference in prior ELA assessment scores. Second, we performed impact analyses of outcomes from the administrative data using the survey sample and compared the results with those based on the full sample. Third, we used a random-effects model to test impacts on the two postsecondary outcomes that did not have estimation problems when the EC effect was modeled as a random effect at the lottery level. Fourth, we conducted the impact analyses for high school graduation, including students with imputed outcome data. We did not include college enrollment and college degree completion in this set of analyses because variables created from NSC data did not have missing data. Finally, we compared the results for selected outcomes using ITT models that excluded baseline characteristics as covariates with the results from our main model.

Overall, the results from these sensitivity tests are consistent with the results from our main impact analyses based on the full sample. The only notable exception is that the EC impact on high school graduation, which was not significant when students with missing outcome data were excluded, became significant when those

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students were included in the impact analysis with imputed outcome data (86.0% for treatment students as compared with 80.6% for control students). Further details of the sensitivity analysis results can be found in Berger et al. (2013).

In addition to the sensitivity analyses, we also conducted complier average treatment effect analyses on key outcomes that explicitly took into account noncompliance with treatment assignment (i.e., no-shows and crossovers). The analyses were based on an instrumental variable approach and estimated the treatment effect on those who complied with their treatment assignment (i.e., compliers) or, in this case, the treatment effect on students who were induced to attend an EC through winning an admission lottery. As expected, the complier effect estimates were larger than the ITT estimates (see Berger et al., 2013, for details).

Summary and Implications

Summary of Findings

Being admitted to an EC had significant positive impacts on students' college enrollment and degree attainment. Our analyses suggest that the college enrollment and degree attainment differences between EC and control students were the largest by the end of the traditional high school experience (4 years after entering ninth grade). These differences narrowed in later years, but statistically significant gaps remained on measures of whether students had ever enrolled in college or earned a degree. Being admitted to an EC, however, did not have a significant impact on high school graduation. Nevertheless, it did have positive impacts on students' high school experiences (e.g., college credits earned during high school, college-going culture, and instructor supports) as reported in Berger et al. (2013).

In addition to ECs' overall impacts, we examined whether the impacts of ECs differed for students with different background characteristics. We found that the impacts of EC on graduation from high school and college enrollment did not differ for students with different characteristics. However, the EC impact on college degree attainment was stronger for minority and low-income students, as well as for students with higher levels of prior achievement relative to their peers. Taken together, these results show that ECs did not leave underrepresented students behind.

Limitations

Our goal for the study was to assess the degree to which ECs improved student outcomes. Such a question could theoretically be answered by randomly assigning students to treatment and control conditions at a randomly selected set of ECs across the country. However, not all ECs used a lottery to determine admissions, and the decision about whether to use an admission lottery was itself not random. To offer a lottery, a school must have had more applicants than it had seats available and must further have used a random assignment process for admissions.[11] Among ECs that used an admission lottery, the study pool was further narrowed to those that had the ability to provide data (particularly lottery records) for this retrospective study. Therefore, the final study sample includes a nonrandom set of ECs, limiting the generalizability of study findings.

Due to these limitations, the study findings cannot be generalized to schools or students outside of the study sample. However, utilizing the set of ECs for which we could verify a random lottery-based admission process offered us the unique opportunity to compare the outcomes of students who were randomly selected to attend an EC through a lottery with the outcomes of students who did not win the lottery but would have otherwise attended the same EC. Thus, despite its limited external validity, this study has strong internal validity built upon a rigorous "gold standard" randomized experimental design.

Another limitation of the study is related to the student population of the study schools. The goal of the ECHSI is to improve the likelihood of college completion for students from underrepresented populations. The ECs included in this study certainly achieved the intended impacts for underrepresented groups. However, the ECs in the study attracted students who were more academically prepared than typical students in their districts. Overall, EC and control students had impressive high school graduation rates, both exceeding 80%. By comparison, the national graduation rate in 2009 to 2010 was 78.2% (NCES, 2013b). College enrollment rates

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for students in the study sample were quite high as well—over 70%. By comparison, only 40% of 18- to 24-year-olds in the nation enrolled in college in 2010 (NCES, 2012b). Therefore, although this study found that the impact of ECs on degree completion was stronger for traditionally underrepresented students, it is important to note that the study sample was not representative of the population of underrepresented students in America.

A final limitation of this study is that it only followed students through 2 to 4 years after high school. It is standard practice for statistics on postsecondary attainment to allow 3 years after starting college to attain an associate's degree and 6 years after starting college to attain a bachelor's degree (NCES, 2012c). Therefore, we cannot definitively answer the question of whether control students might eventually catch up to EC students in terms of degree attainment.

Implications and Directions for Future Research

Despite the above-mentioned limitations, this study yielded strong evidence for the significant and meaningful impacts of ECs on student outcomes. By combining the secondary and postsecondary education systems, the ECHSI challenges the separation between high school and college and provides a different way of thinking about the potential of college. The initiative reengineers and accelerates the educational pathway, and students have experienced significantly greater success following this path.

Questions about the long-term impact of ECs remain, and it would be useful to follow students further into their educational careers and even into the workforce. Further research that considers outcomes for additional years beyond high school is required to determine the longer term impact of ECs on degree attainment and workforce outcomes. Such research will help us understand whether ECs act primarily as an accelerating mechanism, or whether they also produce higher degree attainment and job earnings for students over time.

Nevertheless, the available evidence strongly indicates that EC students completed college ahead of their peers. Even if control students were to catch up over time, ECs offered the benefit of acceleration. Students who earn degrees earlier have the opportunity to enter the workforce earlier and potentially realize additional lifetime earnings. At the same time, earning a college degree while in high school can save money for students and their families because ECs often cover most, if not all, of the college costs incurred during high school.

In addition, benefits of ECs may extend beyond EC students and their families. Earlier research estimated the return on investment based on the assumption that about 48% of EC students and 20% of traditional students would eventually obtain an associate's or bachelor's degree (Palaich, Augenblick, & Maloney, 2007; Vargas, 2013). Under these assumptions, which are appropriate based on the findings from this study, the authors found long-term financial benefits both for EC students and their families and for educational institutions and governments. Therefore, a promising line of future research is to examine the financial impact or return on investment of ECs.

Another line of future research is to look into the mechanisms through which the ECs affect students' postsecondary access and success. This study started to do so by examining the differences between EC students and control students in several key aspects of their high school experiences. Future research may investigate the extent to which the EC impact on student outcomes was mediated by students' high school experiences through a formal mediation analysis, which will shed light on how the ECs achieved their impact on student outcomes.

Finally, this study included a limited number of sites, which did not allow us to examine the potential variation in EC impacts across sites. A natural extension of the current study would be to assess EC impacts across a larger number of sites, which would make it possible to examine both variations in EC impact and factors that may be associated with such variations. Understanding these issues could answer several policy and practice-related questions: What supports do ECs provide, and how do they relate to student success in college? To achieve positive impact, must schools implement the full EC model, or can high schools leverage current dual enrollment policies and include EC components to improve

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student access to and success in college? What is the role of state policy in the success of ECs? These additional lines of future research on ECs will generate valuable insights that will inform policies and practices pertaining to the implementation and scale-up of ECs as a promising dual enrollment model with proven impact on postsecondary education access and attainment for all students—not just academically advanced students.

Authors' Note

This article is adapted from evaluation reports released by the American Institutes for Research (AIR): *Early College, Early Success: Findings From the Early College Impact Study* (Berger, Turk-Bicakci, Garet, Song, Knudson, Haxton, Zeiser, Hoshen, Ford, Stephan, Keating, & Cassidy, 2013) and *Early College, Continued Success: Early College High School Initiative Impact Study* (Berger, Turk-Bicakci, Garet, Knudson, & Hoshen, 2014).

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Declaration of Conflicting Interests

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Notes

1. Of the 154 Early College High Schools (ECs) in the national population, 13 were excluded because no students in the school were in the high school grades, 16 were excluded because they did not have graduates within the study years, 2 were excluded because the EC model was implemented for only some students within the school, 103 were excluded because they were not oversubscribed, and 10 were excluded due to missing lottery records.

2. The EC with the highest no-show rate (about 50% for all three cohorts) is in a district that ran district-wide lotteries for all schools in which each student could participate in multiple school-specific lotteries. Some of the winners of the EC lottery also may have won the lottery of another school that they preferred to attend.

3. Based on the survey sampling rates and response rates, we computed the non-response-adjusted survey weight as the inverse of the product of sampling rate and response rate within each study condition within each lottery. The survey weights were applied to all analyses of survey data so that the results could be generalized to all students included in the survey sample.

4. For a given lottery with m sublotteries, $SUBLOT_{mij}$ was coded −1 for students in the omitted reference sublottery (i.e., if $m = 1$), 1 for students in sublottery m within the given lottery, and 0 for all other students. Given the effect coding, treatment effect for such a lottery represents the equally weighted effect across the m sublotteries within the lottery. There is one set of sublottery indicators for each lottery with sublotteries in the Level 1 equation, although only one set is shown for simplicity.

5. In two of the 17 lotteries, all treatment students were minorities; therefore, these two lotteries were excluded from the analysis of differential effects by minority status. In addition, one lottery was excluded from the analysis of differential effects by free or reduced-price lunch status because only students who did not qualify for free or reduced-price lunch participated in the lottery.

6. The differential effects of EC on college degree attainment based on prior achievement are not presented in Table 4 because prior achievement was included in the model as a continuous measure (i.e., standardized test scores). The odds ratio for the treatment-by-prior achievement in English language arts (ELA) interaction term was 1.8, and the odds ratio for the treatment-by-prior achievement in mathematics interaction term was 2.0. Both estimates were significant at the .05 level. Additional details about these analyses are provided in Berger et al. (2013).

7. We examined college enrollment after the end of Year 4 rather than after high school graduation to take full advantage of available data. Although postsecondary data were requested from the National Student Clearinghouse (NSC) for all students in our sample, some students who dropped out of high school or lacked graduation dates in the administrative records would need to be excluded from the analysis if we only included students

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with known graduation dates. A sensitivity analysis that used the high school graduation date instead of Year 4 to define "after high school" produced college enrollment rates that were higher for both study groups, but these rates remained statistically indistinguishable.

8. The rates of Advanced Placement (AP) course-taking and exam passage may seem high for treatment students considering their access to college courses, but, as noted previously, some treatment students never attended the EC and some transferred out during their high school years. In addition, some ECs also offered AP courses.

9. These descriptive values are unadjusted means.

10. We also examined whether students received general college information from resources outside of school (e.g., family and friends). About 40% of the students in both groups reported having at least one "very helpful" resource for providing them with general college information outside of school (38.8% treatment and 40.0% control—a statistically nonsignificant difference).

11. Although one may assume that only selective, high-performing high schools would have the opportunity to initiate a lottery system due to oversubscription, this was not always the case. In fact, some of the ECs in this study implemented a lottery due to local or state education policies or citywide high school application processes.

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