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INTERVENTION, EVALUATION, AND POLICY STUDIES

Early College, Continued Success: Longer-Term Impact of Early College High Schools

Mengli Song, Kristina Zeiser, Drew Atchison and Iliana Brodziak de los Reyes

American Institutes for Research, Arlington, Virginia, USA

ABSTRACT

Following up on a previous impact study of Early Colleges (EC) based on retrospective admission lotteries, this study assessed longer-term impacts on students' postsecondary outcomes with 4 more years of data. The study found that students who won EC admission lotteries were significantly more likely to enroll in college, enroll in 2-year colleges, complete a college degree, complete associate's degrees or certificates, and complete bachelor's degrees within 6 years after expected high school graduation than control students. Moreover, it found that treatment students completed postsecondary degrees earlier and faster than control students. Consistent with EC's focus on college exposure during high school, the EC impacts on college enrollment and the completion of associate's degrees largely occurred within high school. The study also found that EC impacts did not vary significantly by students' demographic characteristics; however, some impacts were significantly stronger for students with higher levels of prior achievement.

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Introduction

There is substantial evidence that a postsecondary degree or credential prepares students for successful entry into the workforce. A recent study estimated that bachelor's degree holders earn at least $250,000 more over a lifetime than individuals with only a high school diploma (Belfield & Bailey, 2019), and others contend that college degree earners fared better in the recent American recession than adults with only a high school diploma (Grusky et al., 2013). Moreover, workforce projections consistently predict that the lion's share of future jobs will require a postsecondary degree (Carnevale et al., 2011, 2013), with two out of three jobs requiring some education or training after high school and 56% of "good jobs" (paying at least $35,000 for workers aged 25–44 years) requiring a bachelor's or higher degree (Carnevale et al., 2018).

During the past decade, a growing body of research evidence has emerged noting the promise of dual enrollment as an effective way to promote postsecondary access and success. While the implementation of dual enrollment programs varies across schools and may be dictated by state policies, dual enrollment is generally defined as students'

CONTACT Kristina Zeiser kzeiser@air.org American Institutes for Research, 1400, Crystal Drive, 10th Floor, Arlington, VA 22202, USA.

participation in college-level courses that count for credits at both the secondary and postsecondary levels. A recent evidence review conducted by the What Works Clearinghouse (2017a) concluded that dual enrollment programs had positive effects on high school achievement, high school graduation, credit accumulation, college enrollment, and degree completion outcomes, and had potentially positive effects on staying in high school, high school attendance, and college readiness outcomes.

One type of dual enrollment program that has received much attention and has been expanding rapidly across the nation is Early Colleges (ECs), which were created as part of the Early College High School Initiative (ECHSI) established in 2002 by the Bill & Melinda Gates Foundation, along with the Carnegie Corporation of New York, the Ford Foundation, and the W.K. Kellogg Foundation. The explicit goal of the initiative was to increase the opportunity for students from disadvantaged backgrounds to earn a postsecondary credential. To achieve this goal, ECs partner with colleges and universities with the expectation that all students attending ECs will earn an associate's degree or up to 2 years of college credits during high school at no cost or low cost to their families.[1] While traditional dual enrollment programs are typically available only to select students within a school (e.g., high-achieving students), ECs operate at the whole school level so that all students within an EC are expected to take college-level courses and no students are excluded from the college-going experience. ECs also provide a rigorous and supportive high school environment to help students navigate and succeed in college coursework. Since 2002, more than 280 ECs have opened nationwide as part of the ECHSI, serving more than 80,000 students in 31 states and the District of Columbia (Webb, 2014). The number of ECs outside of the ECHSI also has continued to increase across the country.

This article presents the findings from a follow-up study designed to assess the longer-term impacts of ECs by extending a previous EC impact study with 4 more years of student outcome data. This follow-up study addressed the following research questions (RQs) about the longer-term impacts of ECs on student outcomes 6 years after expected high school graduation:

RQ1: Did EC students have better postsecondary outcomes (i.e., college enrollment and degree attainment) than control students?

RQ2: Did the impacts of ECs vary by student background characteristics (i.e., race/ethnicity, low-income status, and prior mathematics and English language arts [ELA] achievement)?

Before presenting detailed findings for each RQ, we provide a brief review of the EC model and existing research on ECs and a description of the methods used to address the RQs.

The EC Model

The EC model was built on the theory of change underlying the ECHSI as illustrated in Figure 1. The underlying assumption of the ECHSI is that engaging students from

[1]ECs employ a variety of approaches to cover students' tuition costs, including tuition payments from the state or district or a college's decision to waive tuition for EC students. Funding availability and local/state policy contexts, however, require that students in some states absorb some or all of this expense (Berger et al., 2009).

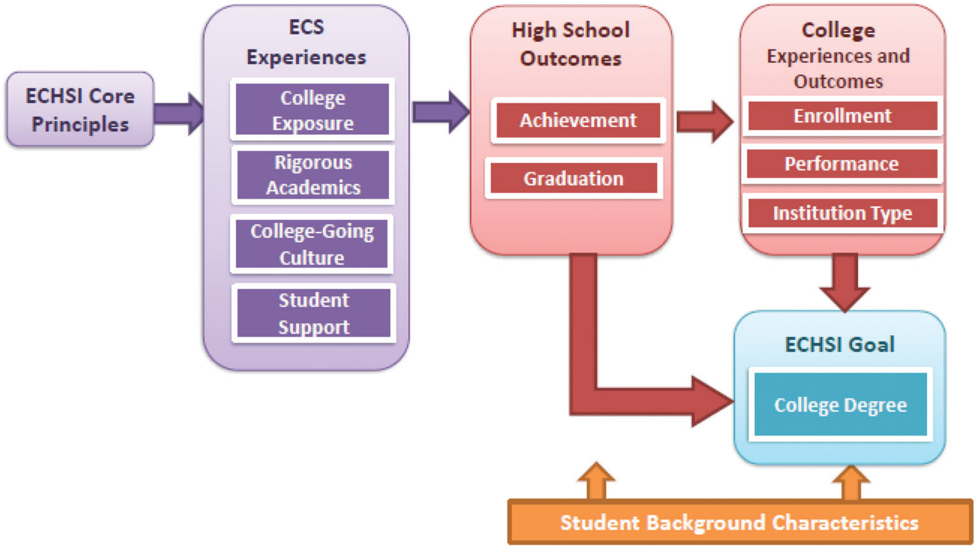

Figure 1. ECHSI theory of change.

underrepresented backgrounds in a rigorous high school curriculum tied to the incentive of earning college credits (with reduced financial burden), and simultaneously supporting students academically and emotionally as they transition out of high school, will increase their access to and success in postsecondary education.

The implementation of the ECHSI was guided by the following five core principles (Jobs for the Future, 2008, p. 2):

1. ECs are committed to serving students underrepresented in higher education.
2. ECs are created and sustained by a local education agency, a higher education institution, and the community, all of whom are jointly accountable for student success.
3. ECs and their higher education partners and community jointly develop an integrated academic program so all students earn 1–2 years of transferable college credit leading to college completion.
4. ECs engage all students in a comprehensive support system that develops academic and social skills as well as the behaviors and conditions necessary for college completion.
5. ECs and their higher education and community partners work with intermediaries to create conditions and advocate for supportive policies that advance the EC movement.

Although all ECs created under the ECHSI follow the same guiding principles, they vary in their structural features. A national evaluation of the ECHSI conducted by Berger et al. (2009) revealed that approximately 70% of ECs in 2007–2008 were public schools while the remaining 30% were public charter schools. In addition, 65% of the ECs each partnered with a public 2-year college, 23% with a public 4-

year college, and 11% with multiple colleges of different types. Where students took a majority of their high school courses also differed across the ECs surveyed in the national evaluation, with over half (53%) of the ECs reporting a college campus, 42% reporting the school building, and 6% reporting another building or distance learning. Although the instructors of college-level courses in some ECs were high school teachers rather than college instructors, most (35) states require instructors of all dual-credit courses to hold the same qualifications as faculty at the associated college in order to ensure the rigor of college-level courses offered at high schools (Horn et al., 2016).[2] In addition, high schools must apply to their states and meet specific standards established by their states in order to be recognized as ECs, which has further ensured the rigor and quality of the college experiences ECs provide to their students.

Research on ECs

Most of the existing research on ECs has been descriptive or qualitative in nature. Findings from qualitative studies of ECs suggest that the opportunities provided by ECs promote supportive and caring relationships between students and teachers, particularly for students who are traditionally underserved in higher education (Beall, 2016; Kaniuka & Vickers, 2010; Pitchford-Nicholas, 2015; Thompson & Ongaga, 2011; Wolk, 2005). Moreover, ECs improve the "clarity of the college-student role" by providing students with a more concrete vision of the types of students who are able to attend college and the types of skills required for success in college (Lile et al., 2018; Newton, 2008; Newton & Vogt, 2008).

The most comprehensive study of ECs to date is a 6-year national evaluation of ECHSI conducted by Berger et al. (2009), which collected data on all 157 ECs open nationwide as of fall 2007. This evaluation examined student achievement and concluded that EC students performed better academically than students in other high schools in the same district. It found, for example, that EC students' proficiency rate on ELA and mathematics state assessments was 7 percentage points higher on average than their peers in the same district. It also estimated that 66% of the students who started at an EC in grade 9 graduated on time, which was 14 percentage points higher than the estimated graduation rate for non-EC students in the same district.

Prior research also showed that EC students performed favorably compared with national figures. Drawing on data from a representative sample of 100 ECs, a 2014 report released by Jobs for the Future, for example, stated that EC students were more likely to graduate high school—90% of EC students received a high school diploma vs. 78% of students nationally—despite the fact that ECs served primarily low-income students and students of color (Webb, 2014, p. 10). The report also noted that EC students were more likely to earn college credits in high school (94% of EC students vs. less than 10% nationally), more likely to complete a college degree by high school graduation (30% of EC students vs. very few students nationally), more likely to enroll in college immediately after high school (71% of EC graduates vs. 54% of low-income high school

[2]This requirement for instructor qualifications applied to all ECs included in the sample of this study.

graduates nationally), and more likely to return to college for a second year (86% of EC graduates who enrolled in college vs. 72% of college students nationally).

While informative, findings from descriptive or qualitative studies of ECs do not warrant causal conclusions about the impact of ECs. A few studies based on quasi-experimental designs produced EC impact findings with stronger causal validity. Miller and Corritore (2013), for example, used propensity score matching to assess the EC impacts on students' college preparedness in mathematics and science by comparing students attending 33 ECs in North Carolina with similar students attending other high schools in the same districts. They found that attending an EC had positive effects on both students' progression through the mathematics pipeline and their mathematics performance, but nil to negative effects on students' science pipeline progression and no effect on their science performance.[3] Also relying on propensity score matching, a more recent study examined the performance of students at 70 of the ECs in North Carolina relative to a matched sample of students who attended the same middle schools but did not attend the ECs during high school (Lauen et al., 2017). This study found significantly better outcomes for EC students in both high school and college, including lower ninth-grade retention rates, higher test scores, fewer absences, higher graduation rates, higher rates of enrollment at 4-year state colleges, and higher rates of completing an associate's degree within 2 or 3 years of high school completion.

To date, the most rigorous evidence on the impact of ECs came from two natural experiments based on admission lotteries. One is the study that is the basis of the follow-up study presented in this article; the other is a study conducted by the SERVE Center at the University of North Carolina at Greensboro (Edmunds et al., 2012, 2013, 2017). Both studies found positive impacts of ECs on a variety of student outcomes both during and after high school. In our previous EC impact study based on retrospective admission lotteries, we found that being offered admission to an EC had positive impacts on high school achievement in ELA and both college enrollment and degree attainment 2–4 years after expected high school graduation (Berger et al., 2013, 2014; Haxton et al., 2016). For example, high school ELA test scores among EC students were approximately 0.14 standard deviations higher than the ELA test scores of control students (Berger et al., 2013). In addition, compared with control students, EC students were significantly more likely to enroll in college (80.7% of EC students vs. 70.7% of control students) and more likely to complete a college degree (23.7% of EC students vs. 2.1% of control students) within 6 years of entering the ninth grade (Haxton et al., 2016).

Taking advantage of EC admission lotteries, the natural experiment conducted by the SERVE Center found that EC students were more likely to be "on track for college" than control students, and that ninth-grade EC students were more likely than control students to take core college preparatory courses and successfully pass end-of-course exams (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). Further analysis of study data revealed that positive impacts on being on track in the ninth grade were stronger among students who would have otherwise attended low-quality high schools (as defined by state-produced school report cards) than among students who would have

[3]Miller and Corritore (2013) suggest that one potential explanation for the lack of effect on science pipeline progression is the difficulty that small ECs face in employing a sufficient number of highly qualified staff to teach multiple science courses, whereas a single highly qualified teacher may teach multiple math courses based on North Carolina certification policies.

otherwise attended a high-quality high school (Miratrix et al., 2018). The SERVE study also demonstrated that EC students accrued significantly more college credits while in high school (21.6 vs. 2.8 credits), and graduated from high school (85.4% vs. 81.4%), enrolled in postsecondary institutions (89.9% vs. 74.3%), and received postsecondary credentials (30.1% vs. 4.2%) at higher rates than control students within 2 years of ending Grade 12 (Edmunds et al., 2017). More recent analyses revealed a positive and statistically significant EC impact on longer-term degree attainment, with 44.3% of the treatment students and 33.0% of the control students earning a postsecondary credential by the end of the sixth year after Grade 12. This finding was largely driven by EC's impact on associate's degree attainment, which was 21.8 percentage points (Edmunds et al., 2020). In contrast, the rate of 4-year degree attainment did not significantly differ between study groups within 6 years after Grade 12 (Edmunds et al., 2020).

Overall, the available research evidence on ECs accumulated over the past decade is quite encouraging. Nevertheless, the evidence base for the EC impact on student outcomes is still understandably thin, given the relatively short history of ECs. Moreover, with the only exception of Edmunds et al. (2020), none of the prior studies have examined the EC impact on longer-term student outcomes beyond 4 years after expected high school graduation. By extending our previous EC impact study with 4 more years of postsecondary data, the follow-up study presented in this article represents a significant addition to the existing evidence base on the impact of ECs on longer-term student outcomes.

Methods

This study is a follow-up study on a previous EC impact study based on retrospective admission lotteries. For both the prior study and the follow-up study, we defined "EC students" or "treatment students" as lottery applicants who were offered enrollment in an EC and "control students" as lottery applicants who were not offered enrollment. Students remained in the treatment group regardless of whether they actually enrolled in EC. By comparing the outcomes of these two groups of students, we can draw valid causal conclusions about the impact of being offered enrollment at ECs.[4]

Sample

To be eligible for inclusion in the original impact study, an EC had to meet the following criteria: (1) enrolled students in Grades 9–12, (2) had high school graduates by 2011, (3) used lotteries in its admission processes for at least one of three incoming student cohorts (i.e., students who entered ninth grade in 2005–2006, 2006–2007, or 2007–2008), (4) retained the lottery records, and (5) implemented the ECHSI as a whole-school program.[5] The study sample was restricted to ECs that were open by fall 2007 to ensure that students in the study would have had the opportunity to complete

[4]To simplify the text, we refer to the impact of ECs in this article; however, EC impacts in this article refer to the effect of receiving the offer to enroll in an EC.

[5]The study team examined lottery records to ensure that random assignment occurred as planned. Students who were admitted to ECs outside of the lottery process (e.g., siblings of students already admitted to ECs) were excluded from the study sample.

at least 2 years of college after expected high school graduation by the end of the original study (2013). For this follow-up study, we collected additional years of postsecondary data to examine student outcomes for 6 years following expected high school graduation for all three student cohorts included in the original impact study.

Of the 154 ECs open nationwide by fall 2007, 10 met the criteria for inclusion in the original impact study. These 10 schools are located in five states (i.e., North Carolina, Ohio, South Carolina, Texas, and Utah); five schools are located in urban areas, two in midsized cities, and three in small towns. Nine schools opened as new schools, and one was an existing school that became an EC. Eight of the ECs had partnerships with 2-year colleges, and the other two with 4-year colleges. All 10 schools were small schools (i.e., fewer than 150 students per grade), with an average enrollment of 290 students (ranging from about 100 to about 600 students). Across the 10 schools, 49% of the students were nonwhite (ranging from 12% to 100%), and 44% were from low-income families (ranging from 9% to 99%) based on 2007–08 data.

Of the 10 ECs identified for the original study, 6 conducted admission lotteries for more than one student cohort, and 3 conducted multiple lotteries (i.e., "sublotteries") in a given year, such as separate lotteries for applicants from different feeder schools or districts. The original study included all students who participated in the 23 lotteries (including sublotteries) across three cohorts conducted by the 10 ECs. In total, the study included 2,458 students (1,044 EC/treatment students and 1,414 control students). The control students were spread across 272 different high schools during the 4 years after participating in the EC admission lotteries, with many of those schools enrolling only one or two control students.

Table 1 presents the background characteristics of the students in each study condition. Group means in achievement test scores in Table 1 are based on *z*-scores, standardized using state averages and standard deviations. Overall, approximately half of the sample was female, half was nonwhite, and half were from low-income families. Fewer than a quarter of study participants had parents who did not attend college (i.e., they were first-generation college goers). The table also shows that students in the study had average Grade 8 ELA and mathematics test scores that were above the state average. Differences between EC students and control students in all the background characteristics examined were small and non-significant ($p > 0.05$).

Table 1. Background characteristics of EC students and control students in the impact study sample.

Student characteristic	EC group mean ($n = 1,044$)	Control group mean ($n = 1,414$)	Group mean difference (effect size)	*p*-Value
Female	51.4%	52.9%	−0.04	0.324
Nonwhite	51.8%	53.3%	−0.04	0.362
Low-income	49.4%	47.3%	0.05	0.312
First-generation college-going	23.9%	22.8%	0.04	0.368
Grade 8 ELA test score	0.212	0.133	0.08	0.068
Grade 8 mathematics test score	0.227	0.236	−0.01	0.392

Notes. The means for EC students are unadjusted means; the means for control students were computed by subtracting the estimated group mean difference from the unadjusted means for EC students. All baseline equivalence tests were conducted using two-level models that were similar to the main impact model.

Data

Data for the original study came from a variety of sources. Information about who participated in the EC admission lotteries and who was offered admission to the EC was obtained from the ECs in the study. Data on students' demographic characteristics and achievement on Grade 8 state assessments were obtained from district and state administrative records. Data for stuents who applied to the three ECs in North Carolina came from a longitudinal experimental study on ECs led by the University of North Carolina at Greensboro SERVE Center. The student demographic and prior achievement data collected in the previous study continue to be available for this follow-up study for all but one EC, which is in a state that no longer allows researcher access to identifiable student-level data. Demographic and prior achievement data for all EC and control students from this site were imputed for the follow-up study.[6] While we included this site in the main impact analyses, we performed a set of sensitivity analyses in which this site was excluded.[7]

Finally, the original study obtained data on students' enrollment in postsecondary education and degree completion as of fall 2013 using the StudentTracker Service from the National Student Clearinghouse (NSC). The NSC collects data on student enrollment and degree completion from more than 3,600 degree-granting higher education institutions, and it covered more than 98% of all student enrollments in public and private colleges and universities in the United States at the time of data collection for the follow-up study. For this follow-up study, we collected additional years of NSC data in winter 2017, allowing for between 6 years (for the youngest cohort) and 8 years (for the oldest cohort) of data after expected high school graduation for students in our study sample. For students without matching records in the NSC database, we assumed that they had not enrolled in college or completed a college degree.[8] Thus, no students in our sample had missing data on postsecondary outcomes by definition.

Measures

Outcome Measures

This follow-up study examined student outcomes in two outcome domains with three primary outcomes in each domain. The primary outcomes were measured during the final year of observation–6 years after expected high school graduation (i.e., Year 10):

- Outcomes in the College Enrollment Domain**:** Enrolled in college, enrolled in a 2-year college, and enrolled in a 4-year college by Year 10.

[6]Procedures for imputing missing background data for this site are identical to the methods applied to participants with missing background data from other study sites. We provide a description of multiple imputation methods in the Analytic Approach section.

[7]Results of these sensitivity analyses largely resemble the results presented in this article, with one exception noted in the later Results section. In addition, for outcome measures that are common between the original study and this follow-up study, results from the original study (where we had actual data for this site) and the follow-up study (where we had imputed data for this site) were generally similar.

[8]This is a reasonable assumption given the NSC's almost universal coverage of postsecondary enrollments in the nation. Even though there is a very slight chance that some students' postsecondary records may be missing from the NSC database, there is no reason to expect the missingness to be related to treatment status or bias the impact estimates.

- Outcomes in the Degree Attainment Domain: Completed any postsecondary degree, completed an associate's degree or a certificate, and completed a bachelor's degree by Year 10.

While our primary outcome measures focus on college enrollment and degree attainment outcomes by Year 10, we also examined whether students enrolled in college, enrolled in a 2-year college, enrolled in a 4-year college, completed any type of postsecondary degree, or completed an associate's degree or a certificate by the end of each year from Year 4 after entering ninth grade through 5 years after expected high school graduation (i.e., by Year 9) as supplemental outcomes.[9] Because students were not expected to earn more than 2 years of college credits during high school and no students in our sample completed a bachelor's degree before Year 6, we examined bachelor's degree completion by the end of each year between Year 6 and Year 9 in addition to degree completion by Year 10.

To further inform our understanding about the timing of EC impacts, we also examined college enrollment and degree completion that occurred after expected high school graduation (i.e., between Year 5 and Year 10), as well as college enrollment *during* each year between Year 4 and Year 10, as supplemental outcome measures. These analyses allowed us to distinguish EC impacts that occurred during high school from impacts after high school. Given that all students who completed a bachelor's degree in this study did so after high school, we did not separately examine bachelor's degree completion between Year 5 and Year 10 because it would be equivalent to bachelor's degree completion by Year 10. In addition, because we would not necessarily expect students who complete a college degree to enroll in college in subsequent years, we examine three different cross-sectional college enrollment measures during each year between Year 4 and Year 10: (1) enrolled in any college, (2) enrolled in any college or had already completed a bachelor's degree, and (3) enrolled in any college or had already completed any type of college degree or certificate. Together, the primary and supplemental outcome measures examined in this study allowed us to depict a comprehensive and fine-grained picture of the EC impacts on students' postsecondary outcomes over time.

Moderators and Covariates

Given the focus of the ECHSI on students who are underrepresented in higher education, we expect that the EC impact may be particularly positive for these students as ECs provide a rigorous high school curriculum and exposure to college-level courses that traditionally underserved students would not otherwise have access to (RQ2). To test this hypothesis, we conducted moderator analyses with the following measures of student background characteristics as potential moderators: race/ethnicity (White versus

[9]Some readers may have the concern that college enrollment by Year 4 might be overaligned with the treatment of this study. However, as we show in this article, many control students also had the opportunity to enroll in college by Year 4, thus college enrollment by Year 4 is not overaligned with the treatment according to Version 4.1 of the What Works Clearinghouse (2020) group design standards. Further, while findings about the EC impacts on shorter-term outcomes may certainly need to be contextualized, our assessment of the EC impacts on longer-term outcomes helps overcome that concern.

nonwhite), low-income family status, and eighth-grade mathematics and ELA achievement scores (standardized based on state means and standard deviations).[10] These measures also were used as covariates to improve the precision of estimates in all our analyses. Other covariates included in our impact models included gender and students' first-generation college-going status, the data for the latter coming from a student survey administered for the original impact study in winter 2011.

Analytic Approach

Main Impact Analyses

Our main impact analyses are intent-to-treat (ITT) analyses, which estimate the impact of being offered admission to an EC through a lottery, regardless of whether the student actually enrolled in the EC.[11] To estimate the overall ITT effects on binary postsecondary outcomes across lotteries, we constructed a two-level hierarchical generalized linear 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. Specifically, the model was specified as follows:

Level-1 Model (Student Level):

$$\log\left[\phi_{ij}/(1-\phi_{ij})\right] = \beta_{0j} + \beta_{1j} \times EC_{ij} + \beta_{2j} \times X_{ij} + \sum\nolimits_{m=2}^{m} (\beta_{3mj} \times SUBLOT_{mij}) \tag{1}$$

where ϕ_{ij} is the probability of experiencing the outcome (e.g., enrolling in college by the end of Year 10) for student i in lottery j; EC_{ij} is a dummy indicator for treatment status (coded 1 if the student won the EC lottery and 0 otherwise, centered on the lottery mean); 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.[12]

[10]The study team also collected student-level data about English learner (EL) status and Individualized Education Program (IEP) status before entering high school. Because only a small percentage of students in our sample were ELs (less than 1%) or had IEPs (7%), we did not include these two variables as covariates in the impact analyses.

[11]Given the presence of noncompliance with treatment assignment (i.e., no-shows and crossovers), we supplemented the ITT analyses with complier average treatment effect (CATE) analyses to estimate the effects of actually attending an EC—as opposed to the effects of being offered admission to an EC through a lottery—for students who complied with their treatment assignment (i.e., compliers). Across the 23 lotteries (including sublotteries) included in this study, no-shows occurred in 18 lotteries, with an overall no-show rate of 20.9% among treatment students. Crossovers occurred in only three lotteries, with an overall crossover rate of 2.0% among control students. Technical details and results of the CATE analyses are available upon request.

[12]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, the 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.

Level-2 Model (Lottery Level):

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{2}$$

$$\beta_{1j} = \gamma_{10} \tag{3}$$

$$\beta_{2j} = \gamma_{20} \tag{4}$$

$$\beta_{3mj} = \gamma_{3m0} \tag{5}$$

The estimate of primary interest from the above model is γ_{10}, which represents a precision-weighted overall treatment effect across all lotteries in the study sample. To facilitate the interpretation of the size of the treatment effects on binary outcomes, we converted the effect estimates into effect sizes by dividing the effect estimates in logged odds ratio by 1.65 (i.e., the Cox index), as recommended by the What Works Clearinghouse (2017b).

Differential Impact Analyses

To answer the second research question about the potential differential impacts of ECs for students with different background characteristics, we added an interaction between treatment status and a given student characteristic into the student-level equation of the main ITT impact model. We explored whether the EC impacts on the six primary outcomes for the study differed significantly by students' minority status, low-income status, and level of prior mathematics and ELA achievement.[13]

Missing Data

By design, all students in the study have data on the outcome measures based on NSC data; however, not all students have data on all measures of student background characteristics. To address missing data on covariates, we used multiple imputations by chained equations (Raghunathan et al., 2001). The multiple imputation model included all outcome measures, covariates, and interaction terms used in addressing the RQs, as well as indicators for treatment status and lotteries. We generated 10 imputed data sets, conducted all analyses using each imputed data set separately, and then combined estimates across the 10 data sets based on standard multiple imputation combination rules, which take into account the uncertainty in imputed values both within and across the imputed data sets (Little & Rubin, 2002).

Findings

This section presents the findings for the two RQs guiding this study. First, we describe the main impact findings for student outcomes in the college enrollment and degree completion domains (RQ1). We graphically present findings for both for cumulative outcomes (e.g., enrolled in any college by Year 8) and cross-sectional outcomes (e.g., enrolled in any college during Year 8). Figures illustrate observed (unadjusted) outcomes among EC students and adjusted outcomes (i.e., the observed outcome among EC

[13]In two of the 23 lotteries, all EC students were minorities; therefore, these two lotteries were excluded from the analysis of differential impact by minority status. In addition, one lottery was excluded from the analysis of differential impact by low-income status because no students in this lottery were from low-income families.

students minus the EC impact estimate) among control group students over time. Vertical bars associated with adjusted control group outcomes in these figures represent 95% confidence intervals; when these vertical bars do not intersect with the observed outcome among EC students, then the difference between groups is statistically significant. Tables that provide detailed results of analyses addressing RQ1 are provided in Tables A1–A3 in the Appendix. We conclude this section by presenting findings of the variation in the EC impact by student background characteristics (RQ2).

EC Impacts on College Enrollment

Our ITT analysis showed that being admitted to an EC had a statistically significant, positive impact on college enrollment within 6 years after expected high school graduation (i.e., by Year 10): 84.2% of EC students had at least one record of college enrollment in the NSC during the time period, roughly 7 percentage points higher than the college enrollment rate for control students (77.0%, see Figure 2). This difference was driven primarily by the much higher rate of enrollment in 2-year colleges for EC students (65.8%) than for the control students (46.8%). The two groups of students did not differ significantly in the rate of enrolling in 4-year colleges by the end of the sixth year after expected high school graduation (57.6% of EC students compared with 56.7% of control students).

For both enrollment in any type of postsecondary institution and enrollment in 2-year colleges, we found that winning an EC lottery had significant impacts on enrollment rates by the end of each year between Year 4 (i.e., the fourth year of high school) and Year 10 (i.e., 6 years after expected high school graduation), although the percentage point

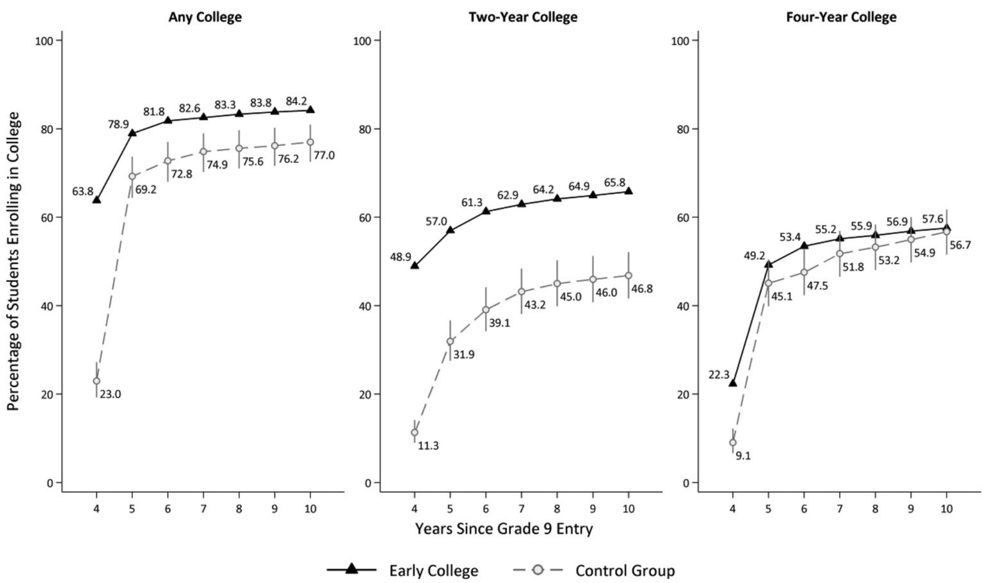

Figure 2. EC impacts on college enrollment outcomes.
Notes. $n = 2{,}458$ (1,044 EC, 1,414 control). The EC group percentages are unadjusted percentages; the control group percentages were computed based on the unadjusted EC group percentages and estimated EC effects. Vertical bars attached to the adjusted control group percentages represent the 95% confidence intervals.

difference between the two study groups tended to decrease over time (see Figure 2). A general decline over time in the size of the EC impact is also evident for enrollment in 4-year colleges, and after Year 6, the EC impact on the rate of enrollment in 4-year colleges was no longer statistically significant.

In addition to the EC impact on college enrollment by the end of each year examined, we estimated the EC impact on college enrollment after expected high school graduation (i.e., between Year 5 and Year 10). The EC impact during this period was not statistically significant for any of the college enrollment outcomes examined (see Table A1 in the Appendix).[14] Therefore, the significant EC impacts on college enrollment outcomes by the end of Year 10 were largely driven by the positive EC impact on students' college enrollment during high school. In other words, the overall impacts on college enrollment and enrollment in 2-year colleges were driven by EC students who experienced college during high school, but for reasons we were unable to measure (e.g., financial, academic, personal, motivational), some of the EC students did not continue their education after the fourth year of high school. Nevertheless, the overall rate of college enrollment after high school (i.e., between Year 5 and Year 10) was still higher for EC students than for control students (78% versus 75%), although the difference was not statistically significant.

EC Impacts on Degree Attainment

The results for the EC impacts on outcome measures in the degree attainment domain are summarized in Figure 3. Within 6 years after expected high school graduation, 45.4% of EC students completed postsecondary degrees, compared with 33.5% of control students. This 12-percentage-point difference was statistically significant and largely driven by the difference between the two study groups in the percentage of students who completed an associate's degree or certificate by the end of Year 10—29.3% of EC students compared with 11.1% of control students, a significant difference exceeding 18 percentage points. The difference between the study groups in bachelor's degree completion by the end of Year 10 was much smaller yet still statistically significant—5.2 percentage points (30.1% of EC students compared with 24.9% of control students).

Figure 3 also reveals that being admitted to an EC had a significant, positive impact on degree completion by the end of each year between Year 4 and Year 10. While the difference in degree completion rates between the EC students and control students remained statistically significant over time, the size of the difference decreased from a maximum of 22.5 percentage points (by the end of Year 6 and Year 7) to 11.9 percentage points (by the end of Year 10). This indicates that EC students completed postsecondary degrees earlier and faster than control students. Although control students began to "catch up" to EC students over time in terms of degree completion, a

[14]Our findings for college enrollment "between Year 5 and Year 10" may overestimate the EC impact on "college enrollment after high school" because, while Year 5 is intended to represent the first year after expected high school graduation, students at three ECs offering 5-year programs may have still been enrolled in the ECs in Year 5. However, in two of these ECs (accounting for 11% of the study sample), the majority (78%) of the EC students actually graduated within 4 years. At only one EC site, the majority of treatment students graduated from high school within 5 years (60%) rather than within 4 years (19%). This site, however, accounted for only 6% of the overall study sample, thus the 5-year high school program attended by some EC students should not substantially affect the interpretation of findings for college enrollment between Year 5 and Year 10.

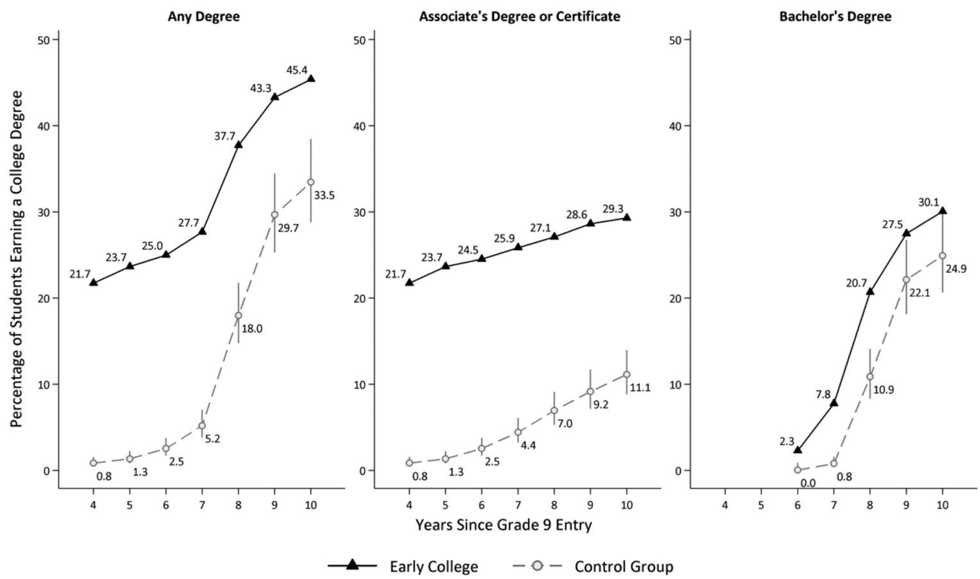

Figure 3. EC impacts on degree completion outcomes.
Notes. $n = 2,458$ (1,044 EC, 1,414 control). The EC group percentages are unadjusted percentages; the control group percentages were computed based on the unadjusted EC group percentages and estimated EC effects. Vertical bars attached to the adjusted control group percentages represent the 95% confidence intervals.

significant difference between the two groups of students remained 6 years after expected high school graduation.

Regarding the completion of an associate's degree or certificate, Figure 3 shows that the percentage-point differences between EC students and control students were largely stable and statistically significant over time. By the end of the fourth year of high school, 21.7% of EC students and less than 1% of control students had completed an associate's degree or certificate. EC-control differences in the rates of associate's degree or certificate completion hovered between 20 and 22 percentage points and remained statistically significant 6 years after expected high school graduation, when the difference reduced slightly to 18.2 percentage points.

Where bachelor's degree completion is concerned, the percentage-point difference between the two study groups first widened and then narrowed, but remained statistically significant, over the time frame we examined. As shown in Figure 3, by the end of Year 6, 2.3% of EC students and virtually 0% (0.03%) of control students had completed a bachelor's degree. By the end of Year 8 (i.e., the fourth year after expected high school graduation), 20.7% of EC students had completed a bachelor's degree, which was almost 10 percentage points higher than the rate for control students (10.9%). This difference narrowed considerably—to 5.2 percentage points (30.1% of EC students and 24.9% control students)—but remained statistically significant by the end of Year 10.[15] These findings again suggest that control students began to "catch up" to EC students over time in

[15]The EC impact on bachelor's degree completion within 6 years after expected high school graduation was slightly smaller and marginally significant ($p = 0.096$) after removing one site where student background data were imputed for all students.

terms of degree completion, but a significant difference between the two groups of students remained 6 years after expected high school graduation.

We also examined the EC impact on the completion of any type of degree as well as the EC impact on the completion of an associate's degree or certificate after expected high school graduation (e.g., between Year 5 and Year 10). As was the case with college enrollment outcomes, we found that the significant EC impacts on the completion of any type of degree and the completion of an associate's degree or certificate by the end of Year 10 were largely driven by the EC impacts on degree completion during high school (see Table A2 in the Appendix). The likelihood of completing any type of degree during the 6 years after high school was similar for EC students (36.0%) and control students (34.1%). The likelihood of completing an associate's degree or certificate after high school, however, was significantly lower for EC students (7.6%) than for control students (11.6%), which is not surprising given that one major goal of ECs is to enable their students to earn an associate's degree *during* high school.

EC Impacts on College Enrollment and Degree Completion During Each Year of Observation

The outcomes described above are cumulative in nature, indicating study participants' college enrollment and degree completion status by the end of each year of observation. In Figure 4, we illustrate EC impacts on cross-sectional measures of college enrollment, or the percentage of EC students and control students who were enrolled in college during each year between Year 4 and Year 10 (see Table A3 in the Appendix for detailed

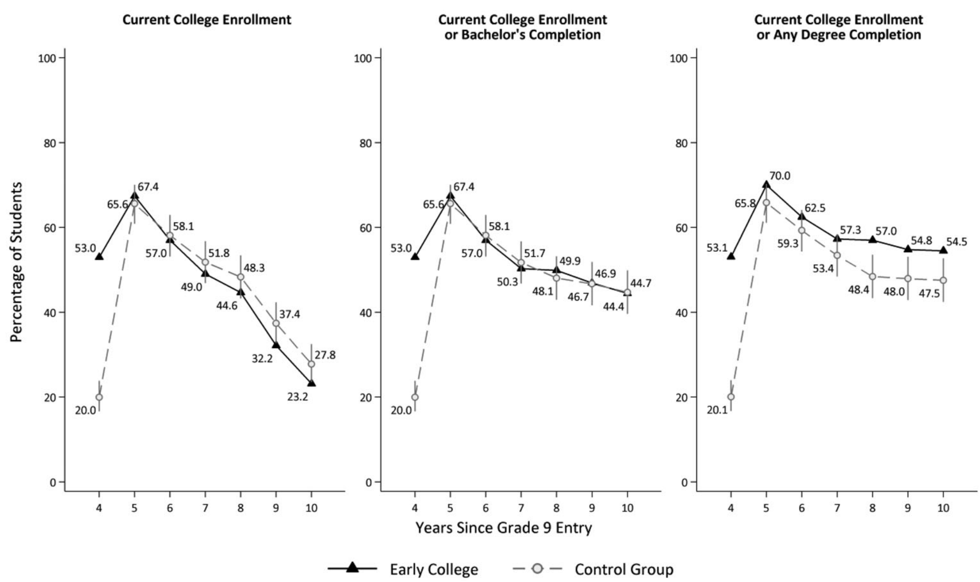

Figure 4. EC impacts on cross-sectional measures of postsecondary outcomes.
Notes. $n = 2{,}458$ (1,044 EC, 1,414 control). The EC group percentages are unadjusted percentages; the control group percentages were computed based on the unadjusted EC group percentages and estimated EC effects. Vertical bars attached to the adjusted control group percentages represent the 95% confidence intervals.

results). Impact estimates in the first panel of Figure 4 indicate that, although EC students were more likely than control students to be enrolled in college during the fourth year of high school, differences between groups in college enrollment during each year between Year 5 and Year 8 were not statistically significant. After Year 8, control students were significantly more likely to be enrolled in college than EC students; during Year 10, 27.8% of control students and 23.2% of EC students were enrolled in college, a significant difference of 4.6 percentage points.

It is likely that significantly lower rates of college enrollment among EC students in later years of observation are due to the fact that EC students were more likely to complete college degrees in earlier years of observation. As we illustrate in the second panel of Figure 4, if we compare the percentage of EC and control students who were enrolled in college or had completed a bachelor's degree during each year of observation, we do not observe significant differences between groups after Year 4. In other words, EC students and control students were similarly likely to have been enrolled in college or to have already completed a bachelor's degree during each year between Year 5 and Year 10, but EC students got a "head start" with higher rates of college enrollment in Year 4 (and higher rates of bachelor's degree completion by the end of each year, as shown in Figure 3).

Finally, in the third panel of Figure 4, we compare the percentage of EC and control students who were either enrolled in college or had already received any type of college degree or certificate during each year between Year 4 and Year 10. These results again show that differences between groups were not statistically significant each year between Year 5 and Year 7, indicating that EC students and control students were similarly likely to be enrolled in college or to have already completed a degree during these years immediately following expected high school graduation. However, we found that EC students were significantly more likely than control students to either be enrolled in college or to have already completed a college degree or certificate each year between Year 8 and Year 10. During Year 10, for example, 54.5% of EC students and 47.5% of control students were either enrolled in college or had already completed a college degree or certificate, a difference of 7 percentage points.

Differential EC Impacts

Overall, we found that the EC impacts on college enrollment and degree attainment outcomes did not significantly differ by students' race/ethnicity or low-income status (see Table A4 in the Appendix for detailed results).[16] However, we did find significant differential impacts based on students' Grade 8 achievement test scores. As shown in Table 2, the EC impact on enrolling in a 2-year college within 6 years after expected high school graduation (i.e., by Year 10) was significantly stronger for students with higher levels of Grade 8 ELA achievement than for students with lower levels of prior ELA achievement.

[16]It is possible that the lack of significant differential impacts may be due to insufficient statistical power. In particular, analyses focusing on differential impacts by race/ethnicity were based on a substantially reduced sample size because two lotteries with over 600 students in total were excluded from these analyses given that 100% of the students in these lotteries were minority students.

Table 2. Differential EC impacts on college enrollment and degree attainment outcomes by the end of Year 10, by prior achievement.

Outcome by the end of year 10	Prior ach. = 1 SD below average			Prior ach. = average			Prior ach. = 1 SD above average			Differential impact	
	EC group probability	Control group probability	Diff.	EC group probability	Control group probability	Diff.	EC group probability	Control group probability	Diff.	Odds ratio	*p*-Value
Differential impact by prior ELA achievement											
College enrollment	81.9%	75.2%	6.7%	87.4%	81.0%	6.3%	91.3%	85.8%	5.6%	1.1	0.601
2-year college enrollment	69.8%	59.2%	10.6%	80.2%	64.8%	15.5%	87.7%	70.0%	17.8%	1.4	0.011
4-year college enrollment	38.1%	38.8%	−0.7%	50.3%	49.6%	0.8%	62.6%	60.3%	2.2%	1.1	0.623
Completed any degree	31.6%	24.7%	6.9%	42.2%	31.4%	10.8%	53.6%	38.9%	14.6%	1.1	0.398
Completed an associate's degree or certificate	22.7%	14.6%	8.1%	36.2%	16.4%	19.8%	52.4%	18.5%	33.9%	1.7	0.004
Completed a bachelor's degree	13.2%	11.7%	1.5%	20.2%	16.8%	3.4%	29.6%	23.7%	6.0%	1.1	0.611
Differential impact by prior mathematics achievement											
College enrollment	82.8%	74.4%	8.4%	87.0%	81.0%	6.1%	90.4%	86.2%	4.2%	1.0	0.744
2-year college enrollment	75.0%	62.4%	12.7%	80.1%	64.8%	15.3%	84.3%	67.2%	17.2%	1.2	0.099
4-year college enrollment	37.1%	38.4%	−1.3%	50.3%	49.6%	0.7%	63.4%	60.8%	2.6%	1.1	0.500
Completed any degree	27.4%	22.2%	5.3%	41.8%	31.4%	10.3%	57.7%	42.5%	15.2%	1.2	0.272
Completed an associate's degree or certificate	21.0%	15.7%	5.3%	35.1%	16.5%	18.5%	52.3%	17.4%	34.9%	1.9	0.000
Completed a bachelor's degree	14.0%	10.4%	3.6%	21.2%	16.8%	4.4%	30.9%	26.1%	4.8%	0.9	0.742

Notes. Ach. = achievement; Diff. = difference; ELA = English language arts; SD = standard deviation; $n = 2{,}458$ (1,044 EC, 1,414 control).
The EC and control group probabilities for a given level of prior achievement (i.e., 1 SD below the state average, state average, and 1 SD above the state average) are predicted probabilities when all control variables other than the prior achievement measure were set to their grand means. The values in the Diff. columns may not match the difference between the EC and control group probabilities due to rounding.

The differential impact of ECs on this outcome by students' Grade 8 mathematics achievement was similar in magnitude but only marginally significant ($p < 0.10$).

Table 2 also shows that the EC impact on completing an associate's degree or certificate within 6 years after expected high school graduation was significantly stronger for students with higher levels of Grade 8 achievement in ELA and for students with higher levels of Grade 8 achievement in mathematics than for students with lower levels of prior achievement. We did not observe significant differential impacts on the other college enrollment and degree attainment outcomes by students' prior achievement levels.

Summary and Discussion

Summary of Findings

With additional years of data collected after the completion of the original EC impact study, this follow-up study assessed longer-term impacts of ECs on students' college enrollment and degree attainment outcomes as well as differential EC impacts based on student background characteristics. Below, we summarize the findings associated with each of the two RQs addressed in this study.

EC Impacts on Students' Postsecondary Outcomes (RQ1)

We found that the positive EC impacts observed in the original impact study continued over the time period examined in this follow-up study. EC students had a higher overall college enrollment rate and a higher 2-year college enrollment rate on average than control students by the end of each academic year between the fourth year of high school and 6 years after expected high school graduation. By the end of Year 10 after starting high school, approximately two-thirds (65.8%) of EC students enrolled in 2-year colleges, compared with fewer than half (46.8%) of control students ($p < 0.001$). However, additional analyses revealed that although the EC impact on college enrollment after expected high school graduation (i.e., between Year 5 and Year 10) still favored the EC group, it was no longer statistically significant, suggesting that the positive EC impacts on college enrollment observed during the 10 years after starting high school were largely driven by EC students enrolling in college while in high school.

Because eight of the 10 ECs in our study partnered with 2-year colleges, one might anticipate that EC students in our study would be less likely to enroll in 4-year colleges than control students. However, this is not what we found. Although the EC-control difference in 4-year college enrollment rates narrowed over time and was no longer statistically significant after Year 6, control students did not fully catch up with the EC students by the end of the sixth year after expected high school graduation (Year 10), when 57.6% of EC students had enrolled in 4-year colleges, as compared with 56.7% of control students.

Where degree attainment is concerned, the extended timeline of this follow-up study allowed us to observe that the positive EC impacts on college enrollment translated into significant differences in degree completion outcomes between EC students and control students. Within 6 years after expected high school graduation, 45.4% of EC students—compared with 33.5% of control students—completed a postsecondary degree.

Significant impacts were also observed for both the completion of an associate's degree or certificate (29.3% of EC students vs. 11.1% of control students) and the completion of a bachelor's degree (30.1% of EC students vs. 24.9% of control students) within 6 years after expected high school graduation. Of particular note is that we observed a significant, positive EC impact on bachelor's degree completion 6 years after expected high school graduation despite the fact that we did not observe a significant impact on enrollment in 4-year colleges by that time point. This finding perhaps suggests that EC students were better *prepared* for their education at 4-year colleges, and/or that they were able to complete the degree *faster* (within 6 years after expected high school graduation) because of their early exposure to college during high school. Although most of the ECs in our study partnered with 2-year colleges, it appears that EC students' experiences with these colleges played a supportive role in their pursuit and completion of bachelor's degrees.

Findings of the EC impacts on degree attainment over time indicate that EC students not only were more likely to complete postsecondary degrees, but they also completed postsecondary degrees *more quickly* than control students. Further follow-up on these students would be necessary to determine whether differences in bachelor's degree completion between EC and control students would continue to persist over time. However, the fact remains that a larger percentage of EC students completed postsecondary degrees earlier in their lives, allowing them to either get a head start on furthering their education or entering the labor force with such credentials at a younger age, which has implications for potential lifetime earnings.

Differential EC Impacts (RQ2)

While the EC impacts on the primary postsecondary outcomes examined in this study did not vary significantly by students' demographic characteristics (i.e., race/ethnicity and low-income status), the EC impacts on some outcomes did vary for students with different levels of prior achievement. Specifically, we found that the EC impact on enrollment in 2-year colleges by Year 10 was significantly stronger for students with higher levels of Grade 8 ELA achievement, and the EC impact on the completion of an associate's degree or certificate by Year 10 was significantly stronger for students with higher levels of Grade 8 ELA or mathematics achievement. One possible explanation is that, because most of the ECs in our study partnered with 2-year colleges, higher-achieving students in ECs might have been more likely to enroll in 2-year colleges (and subsequently complete an associate's degree or certificate) during or immediately after high school relative to higher-achieving students in the control group who may have entered directly into 4-year colleges after graduating from high school. We did not observe significant differential impacts on enrollment in 4-year colleges or completion of a bachelor's degree by levels of prior achievement, indicating that starting at a 2-year college did not prevent higher-achieving EC students from pursuing a 4-year college degree.

Study Limitations

Randomization of students through lottery-based admissions offered us the opportunity to draw valid causal conclusions about the impacts of ECs on student outcomes, including longer-term outcomes, in a timely manner. The drawback, however, is that the estimated impacts only apply to the 10 ECs that participated in our study and cannot be generalized to the over 200 ECs that currently operate nationwide. Not all ECs use lotteries to determine admissions, and the decision about whether to use an admission lottery is itself not random. To offer a lottery, a school must have more applicants than it has seats available and must further use a random assignment process for admissions.[17] In addition, to be eligible for inclusion in a retrospective study such as ours, ECs that used an admission lottery must also be able to provide lottery records to verify that random assignment occurred and to allow the study team to identify the treatment and control students among lottery participants. Therefore, as with any study relying on retrospective admission lotteries, our study includes a nonrandom set of ECs, limiting the generalizability of study findings.

Further, given the retrospective nature of the study, the results of our study may not apply to students who currently attend these ECs. Students in our sample entered Grade 9 between 2005–2006 and 2007–2008, and many aspects of the ECs themselves—such as staff and administration, partnership with the postsecondary institution, and admission processes—may have changed over time. In addition, changes in education policies at the local, state, and national levels have brought an increased focus on college and career readiness for all students, including those who do not attend ECs. Therefore, while this study provides a rigorous assessment of the longer-term impacts of ECs on students who entered ECs over a decade ago, continued research will be necessary to determine whether positive impacts also occur for the current generation of EC students.

Another limitation of the study is related to the characteristics of the student participants. While over half of the students in the study sample were racial minority students and almost half of the students were from low-income families—reflecting the ECHSI’s commitment to serving students from underrepresented populations—the students in our study sample were more academically prepared than typical students in their states. On average, students in our study had Grade 8 test scores that were approximately 0.2 standard deviations above the state average. Therefore, it is important to note that the students in our study sample were not representative of the population of underrepresented students in their states.

Because of these limitations, the study findings may not be generalizable to ECs or students outside of the study sample. However, the set of ECs in this study 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.

Implications and Directions for Future Research

This follow-up study focused on the EC impacts on college enrollment and degree attainment outcomes. One natural extension of this study is research that assesses the

[17]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 admission lotteries due to local or state education policies, or as part of citywide high school application processes.

EC impacts on longer-term outcomes related to students' employment and earnings. It is possible that the higher rates and earlier timing of degree completion for EC students would lead to better labor market outcomes (e.g., employment, career advancement, and income) for these students in the long run. In addition, we hypothesize that, because EC students were more likely to receive college credits during high school at little or no cost to their families, EC students would accrue less student loan debt over time than control students. Until we have collected data on students' workforce and financial outcomes, we can only conjecture about these longer-term impacts.

Additional research is also needed to better understand the EC impacts on certain shorter-term or intermediate student outcomes. Future research may explore the potential mediating roles of intermediate outcomes such as students' high school experiences, "college knowledge" (e.g., knowledge about college applications and college course selection) and social-emotional learning outcomes (e.g., self-efficacy and self-management). In addition, experiencing college during high school likely benefits students by introducing them to role models and mentors (such as college professors, advisors, or classmates), teaching them new study habits, and highlighting the benefits of college attendance both to students and to their parents. Examinations of these intermediate outcomes that occur during high school may further elucidate the EC impacts on students' postsecondary outcomes.

Where study sample and external validity are concerned, one avenue for future research is a focus on more recent cohorts of EC students from a more representative sample of ECs. Findings from such research would shed light on whether the positive EC impacts observed within our sample of ECs apply to the larger population of ECs, and how EC impacts may have changed over time as the characteristics of the ECs (as well as the opportunities available to students who do not attend ECs) have changed over time.

Finally, the small number of sites in this study limited our ability to explore potential variation in EC impacts across sites. Future research on EC impacts that includes a larger number of sites could examine both variations in EC impacts and factors that may be associated with such variations. Such research could inform several policy- and practice-relevant questions: Which supports most strongly relate to EC impacts on students' postsecondary outcomes? Can traditional high schools leverage current dual enrollment policies and include EC components to improve 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 students' postsecondary success.

Declaration of Interest Statement

The opinions expressed in this research are those of the authors and do not represent the views of the Institute or the U.S. Department of Education.

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Appendix

Table A1. ITT estimates of the overall EC impacts on college enrollment outcomes.

Outcome	Effect in logits	Standard error	EC group probability	Control group probability	Percentage point difference	Effect size	p-Value
College enrollment by Year 4	1.78	0.12	63.8%	23.0%	40.8%	1.076	0.000
College enrollment by Year 5	0.51	0.11	78.9%	69.2%	9.7%	0.308	0.000
College enrollment by Year 6	0.52	0.12	81.8%	72.8%	9.0%	0.315	0.000
College enrollment by Year 7	0.46	0.12	82.6%	74.9%	7.7%	0.282	0.000
College enrollment by Year 8	0.48	0.12	83.3%	75.6%	7.7%	0.290	0.000
College enrollment by Year 9	0.48	0.12	83.8%	76.2%	7.6%	0.292	0.000
College enrollment by Year 10	0.46	0.12	84.2%	77.0%	7.2%	0.281	0.000
College enrollment between Year 5 and Year 10	0.16	0.11	78.0%	75.0%	2.9%	0.099	0.147
2-year college enrollment by Year 4	2.02	0.13	48.9%	11.3%	37.6%	1.222	0.000
2-year college enrollment by Year 5	1.04	0.11	57.0%	31.9%	25.1%	0.630	0.000
2-year college enrollment by Year 6	0.90	0.11	61.3%	39.1%	22.2%	0.548	0.000
2-year college enrollment by Year 7	0.80	0.11	62.9%	43.2%	19.7%	0.487	0.000
2-year college enrollment by Year 8	0.78	0.11	64.2%	45.0%	19.2%	0.475	0.000
2-year college enrollment by Year 9	0.78	0.11	64.9%	46.0%	18.9%	0.472	0.000
2-year college enrollment by Year 10	0.78	0.11	65.8%	46.8%	19.0%	0.474	0.000
2-year college enrollment between Year 5 and Year 10	−0.03	0.10	43.4%	44.0%	−0.7%	−0.016	0.783
4-year college enrollment by Year 4	1.06	0.17	22.3%	9.1%	13.2%	0.642	0.000
4-year college enrollment by Year 5	0.17	0.11	49.2%	45.1%	4.1%	0.101	0.128
4-year college enrollment by Year 6	0.24	0.11	53.4%	47.5%	5.9%	0.144	0.026
4-year college enrollment by Year 7	0.14	0.11	55.2%	51.8%	3.4%	0.083	0.196
4-year college enrollment by Year 8	0.11	0.11	55.9%	53.2%	2.7%	0.066	0.300
4-year college enrollment by Year 9	0.08	0.11	56.9%	54.9%	2.0%	0.048	0.455
4-year college enrollment by Year 10	0.03	0.11	57.6%	56.7%	0.9%	0.021	0.744
4-year college enrollment between Year 5 and Year 10	0.05	0.11	56.4%	55.2%	1.2%	0.030	0.643

Notes. $n = 2,458$ (1,044 EC, 1,414 control).
The EC group percentages are unadjusted percentages; the control group percentages were computed based on the unadjusted EC group percentages and estimated EC effects. We computed the effect sizes for these binary outcomes by dividing the logged odds ratio by 1.65 (i.e., the Cox index), as recommended by the WWC.
Year x, $x = 4 \sim 10$, refers to x years after starting high school.

Table A2. ITT estimates of the overall EC impacts on degree attainment outcomes.

Outcome	Effect in logits	Standard error	EC group probability	Control group probability	Percentage point difference	Effect size	*p*-Value
Completed any degree by Year 4	3.49	0.31	21.7%	0.8%	20.9%	2.116	0.000
Completed any degree by Year 5	3.12	0.26	23.7%	1.3%	22.4%	1.893	0.000
Completed any degree by Year 6	2.55	0.21	25.0%	2.5%	22.5%	1.546	0.000
Completed any degree by Year 7	1.94	0.16	27.7%	5.2%	22.5%	1.178	0.000
Completed any degree by Year 8	1.02	0.12	37.7%	18.0%	19.7%	0.616	0.000
Completed any degree by Year 9	0.59	0.11	43.3%	29.7%	13.6%	0.360	0.000
Completed any degree by Year 10	0.50	0.11	45.4%	33.5%	11.9%	0.305	0.000
Completed any degree between Year 5 and Year 10	0.08	0.11	36.0%	34.1%	1.9%	0.051	0.454
Completed an associate's degree or certificate by Year 4	3.49	0.31	21.7%	0.8%	20.9%	2.116	0.000
Completed an associate's degree or certificate by Year 5	3.12	0.26	23.7%	1.3%	22.4%	1.893	0.000
Completed an associate's degree or certificate by Year 6	2.52	0.21	24.5%	2.5%	22.0%	1.530	0.000
Completed an associate's degree or certificate by Year 7	2.02	0.17	25.9%	4.4%	21.5%	1.223	0.000
Completed an associate's degree or certificate by Year 8	1.61	0.15	27.1%	7.0%	20.1%	0.973	0.000
Completed an associate's degree or certificate by Year 9	1.38	0.14	28.6%	9.2%	19.4%	0.837	0.000
Completed an associate's degree or certificate by Year 10	1.20	0.13	29.3%	11.1%	18.2%	0.725	0.000
Completed an associate's degree or certificate between Year 5 and Year 10	−0.47	0.17	7.6%	11.6%	−4.0%	−0.283	0.006
Completed a bachelor's degree by Year 6	4.30	1.70	2.3%	0.0%	2.3%	2.608	0.011
Completed a bachelor's degree by Year 7	2.35	0.36	7.8%	0.8%	7.0%	1.425	0.000
Completed a bachelor's degree by Year 8	0.76	0.15	20.7%	10.9%	9.8%	0.461	0.000
Completed a bachelor's degree by Year 9	0.29	0.13	27.5%	22.1%	5.4%	0.175	0.023
Completed a bachelor's degree by Year 10	0.26	0.12	30.1%	24.9%	5.2%	0.157	0.037

Notes. $n = 2{,}458$ (1,044 EC, 1,414 control).
The EC group probabilities are unadjusted probabilities; the control group probabilities were computed based on the unadjusted EC group probabilities and estimated EC effects. We computed the effect sizes for these binary outcomes by dividing the logged odds ratio by 1.65 (i.e., the Cox index), as recommended by the WWC.
Year x, $x = 4 \sim 10$, refers to x years after starting high school.

Table A3. ITT estimates of the overall EC impacts on cross-sectional college enrollment outcomes.

Outcome	Effect in logits	Standard error	EC group probability	Control group probability	Percentage point difference	Effect size	*p*-Value
College enrollment in Year 4	1.51	0.12	53.0%	20.0%	33.0%	0.914	0.000
College enrollment in Year 5	0.08	0.10	67.4%	65.6%	1.8%	0.050	0.428
College enrollment in Year 6	−0.05	0.10	57.0%	58.1%	−1.1%	−0.028	0.655
College enrollment in Year 7	−0.11	0.10	49.0%	51.8%	−2.8%	−0.067	0.274
College enrollment in Year 8	−0.15	0.10	44.6%	48.3%	−3.7%	−0.090	0.156
College enrollment in Year 9	−0.23	0.11	32.2%	37.4%	−5.2%	−0.139	0.030
College enrollment in Year 10	−0.24	0.11	23.2%	27.8%	−4.6%	−0.147	0.034
College enrollment or already received bachelor’s degree in Year 4	1.51	0.12	53.0%	20.0%	33.0%	0.914	0.000
College enrollment or already received bachelor’s degree in Year 5	0.08	0.10	67.4%	65.6%	1.8%	0.050	0.428
College enrollment or already received bachelor’s degree in Year 6	−0.05	0.10	57.0%	58.1%	−1.1%	−0.028	0.655
College enrollment or already received bachelor’s degree in Year 7	−0.06	0.10	50.3%	51.7%	−1.5%	−0.035	0.568
College enrollment or already received bachelor’s degree in Year 8	0.07	0.10	49.9%	48.1%	1.8%	0.045	0.482
College enrollment or already received bachelor’s degree in Year 9	0.01	0.11	46.9%	46.7%	0.2%	0.005	0.933
College enrollment or already received bachelor’s degree in Year 10	−0.01	0.11	44.4%	44.7%	−0.3%	−0.006	0.921
College enrollment or already received any college degree or certificate in Year 4	1.50	0.12	53.1%	20.1%	33.0%	0.911	0.000
College enrollment or already received any college degree or certificate in Year 5	0.19	0.10	70.0%	65.8%	4.2%	0.116	0.066
College enrollment or already received any college degree or certificate in Year 6	0.13	0.10	62.5%	59.3%	3.2%	0.080	0.203
College enrollment or already received any college degree or certificate in Year 7	0.16	0.10	57.3%	53.4%	3.9%	0.095	0.127
College enrollment or already received any college degree or certificate in Year 8	0.34	0.10	57.0%	48.4%	8.6%	0.209	0.001
College enrollment or already received any college degree or certificate in Year 9	0.27	0.10	54.8%	48.0%	6.8%	0.166	0.009
College enrollment or already received any college degree or certificate in Year 10	0.28	0.11	54.5%	47.5%	7.0%	0.169	0.008

Notes. $n = 2{,}458$ (1,044 EC, 1,414 control).
The EC group probabilities are unadjusted probabilities; the control group probabilities were computed based on the unadjusted EC group probabilities and estimated EC effects. We computed the effect sizes for these binary outcomes by dividing the logged odds ratio by 1.65 (i.e., the Cox index), as recommended by the WWC.
Year x, $x = 4 \sim 10$, refers to x years after starting high school.

Table A4. Differential EC impacts on college enrollment and degree attainment outcomes by the end of year 10, by student background characteristics.

	X = 1				X = 0				Differential Impact		
Outcome by the end of year 10	EC group probability	Control group probability	Diff.	*n*	EC group probability	Control group probability	Diff.	*n*	Odds ratio	Difference in impact	*p*-Value
Differential Impact by Race/Ethnicity (X = 1 for nonwhite)											
College enrollment	84.5%	79.2%	5.3%	954	87.2%	78.5%	8.6%	866	0.8	−3.3%	0.372
2-year college enrollment	72.9%	54.5%	18.4%	954	62.6%	36.8%	25.8%	866	0.8	−7.4%	0.316
4-year college enrollment	59.8%	56.9%	2.9%	954	59.6%	61.3%	−1.7%	866	1.2	4.7%	0.436
Completed any degree	44.7%	30.9%	13.8%	954	53.3%	40.7%	12.6%	866	1.1	1.2%	0.729
Completed an associate's degree or certificate	31.2%	9.4%	21.8%	954	33.1%	13.0%	20.0%	866	1.3	1.7%	0.327
Completed a bachelor's degree	32.1%	24.8%	7.3%	954	33.0%	29.4%	3.6%	866	1.2	3.7%	0.463
Differential Impact by Low-Income Family Status (X = 1 for students from low-income families)											
College enrollment	81.4%	72.2%	9.2%	1,313	87.8%	81.0%	6.7%	1,075	1.0	2.5%	0.983
2-year college enrollment	65.0%	44.4%	20.5%	1,313	66.4%	47.6%	18.8%	1,075	1.1	1.7%	0.794
4-year college enrollment	53.2%	51.4%	1.8%	1,313	62.7%	61.9%	0.8%	1,075	1.0	1.0%	0.865
Completed any degree	38.8%	25.6%	13.2%	1,313	52.8%	40.6%	12.2%	1,075	1.1	1.0%	0.620
Completed an associate's degree or certificate	27.2%	8.9%	18.3%	1,313	31.5%	12.7%	18.8%	1,075	1.2	−0.6%	0.520
Completed a bachelor's degree	24.3%	19.2%	5.1%	1,313	36.4%	30.7%	5.7%	1,075	1.0	−0.6%	0.872

Notes: Diff. = difference. The EC group probabilities within a given student subgroup are unadjusted probabilities; the control group probabilities were computed based on the unadjusted EC group probabilities and estimated EC effects within the subgroup. The values in the Diff. columns may not match the difference between the EC and control group probabilities due to rounding. Two lotteries were excluded from the analyses of differential impact by minority status because zero EC students were nonminority, and thus EC impacts among nonminority students could not be estimated within these lotteries. Similarly, one lottery was removed from the analyses of differential impact by low-income status because zero students within this lottery were from low-income families.