Early Colleges at Scale: Impacts on Secondary and Postsecondary Outcomes

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We examine the impacts of early college high schools, small schools of choice located on college campuses. These schools provide a no-cost opportunity for students to earn college credit—or a 2-year degree—while in high school. Using rich administrative data on multiple cohorts of students and quasiexperimental methods informed by the within-study comparison literature, we estimate program impacts of enrolling in a North Carolina early college in ninth grade on a variety of secondary and postsecondary outcomes. We include all such schools in the state, and we report generally promising findings. Early colleges increase important high school outcomes, boost associate's degree completion, and raise 4-year-college enrollment at less selective public institutions. We also show the differences of these impacts across race, home-district performance, and host site, helping us better understand the implementation and effects of this promising intervention in one state that has brought this school reform model to scale.

National statistics paint a bleak picture of college and career readiness. Only 80% of students graduate from high school on time (Stetser and Stillwell 2014). Then, 20% of high school graduates require remedial education in colleges and universities (Sparks and Malkus 2013). Three in five employers rate students'

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basic skills as "fair" or "poor" (Achieve 2004). Current economic conditions are not favorable, with youth and young adult labor-force participation rates at 20-year lows (Bureau of Labor Statistics 2013). Many working-class and poor students face significant barriers in navigating the college application process and end up failing to enroll or "under-matching" relative to their qualifications (Roderick et al. 2008, 2009). Income-based gaps in test scores, college enrollment, and college completion are increasing (Duncan and Murnane 2011).

Given these facts, one might question whether high schools are succeeding in promoting college and career readiness for all students and what is known about reforming high schools. A meta-analysis of comprehensive school reforms from Borman et al. (2003) found significant improvements in student achievement among reforms maintained for at least 5 years. Reforms that set high goals for students and included collaborative student support had the most significant positive results (Borman et al. 2003). A synthesis of effective high school reforms concludes that the keys for driving high school reform are "1) creating a personalized and orderly learning environment, 2) assisting students who enter high school with poor academic skills, 3) improving instructional content and practice, 4) preparing students for the world beyond high school, and 5) stimulating change in overstressed high schools" (Quint 2006, iii). Waldron and McLeskey (2010) identify collaboration, along with strong leadership and quality professional development for teachers, as important comprehensive reform elements. Rigorous evaluations of high school reform efforts implementing approaches that conform with some combination of these identified practices have reported positive impacts from New York City's rapid infusion of new small schools of choice (Bloom et al. 2010) and from career academy, Talent Development, and First Things First models (Quint 2006).

Our study focuses on a particularly promising high school reform that incorporates many elements of successful secondary reform. Between 2002 and 2014, more than 240 early college high schools (ECHSs) have emerged to smooth the transition from high school to college, especially for minority and economically disadvantaged youth. ECHSs are small schools of choice primarily located on college campuses designed to provide students a no-cost opportunity to earn college credit—or even a 2-year degree—while in high school. To date, two experimental studies on small samples of schools, one retrospective and one pro-

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spective, have produced consistent and promising results, with positive impacts on being on track for college, high school graduation, college enrollment, and associate's degree completion (Berger et al. 2013, 2014; Edmunds et al. 2012; Edmunds, Unlu, et al. 2013; Unlu et al. 2014).

The primary aim of this study is to provide evidence about the effectiveness of all ECHSs in North Carolina, a state in which the model is mature, well supported by an intermediary organization, and implemented at scale, with 78 sites, more than any other state. Only a minority of ECHSs hold admission lotteries, so this will be a quasiexperimental (QE) evaluation, but one with strong internal validity because it will be based on the lessons learned from the within-study comparison (WSC) literature.[1] Estimates of the ECHS effects of all schools in North Carolina will provide policy makers and researchers a more complete picture of ECHS performance by supplementing existing studies with data from a broader range of ECHSs situated in a wider variety of districts with comparison high schools of varying quality.

The second aim is to explore treatment-effect heterogeneity across student subgroups, high- and low-performing districts across the state, and 2- and 4-year campuses, which is made possible with the complete set of ECHSs in North Carolina in the present study. This moderation analysis across student subgroups will explore whether intervention is more or less effective for black and economically disadvantaged students, two subgroups underrepresented in higher education and targeted by the intervention. Our focus on examining differences across low- and high-performing districts is driven by the fact that both randomized controlled trial (RCT) and QE impacts of school interventions in authentic settings are always relative to the counterfactual of the default alternatives in a particular setting (Lemons et al. 2014). Impacts are likely to be larger in areas where neighborhood high schools are weaker and smaller in areas where the alternatives are stronger. Finally, we focus on the differences between 2- and 4-year campuses because institutional capacity and resources vary along this dimension, and those differences likely influence the outcomes associated with the ECHS partnered with the campus, especially those related to postsecondary enrollment.

Background

What Are Early College High Schools?

ECHSs are small (a maximum of 400 students) schools of choice primarily located on campuses of 2- or 4-year colleges or universities. Students who attend these schools have the opportunity to earn, at no financial cost to them, 2 years

of transferable college credit or an associate's degree while simultaneously satisfying high school graduation requirements. Students choose whether to apply to these schools, rather than being assigned based on their place of residence. Many have space for all students who apply. However, at some schools there are not enough slots to accommodate the number of applicants. In these cases, lotteries are often used to select which of the applicants will be invited to enroll.

ECHSs are designed to smooth the transition from high school to college for students who often run into serious barriers on the path to enrolling and staying in college (Roderick et al. 2008, 2009). As part of their mission, ECHSs seek to serve historically underserved populations, including first-generation college students and students at risk of dropping out of high school. Schools may conduct interviews and typically seek to recruit students who are academically prepared to complete a rigorous sequence of coursework. These two arguably conflicting aims—to serve both economically and academically disadvantaged youth and students prepared to succeed in college-level coursework—combined with the fact that these are schools of choice raise the strong possibility of differences in student populations between ECHSs and traditional public high schools and perhaps even across different ECHS sites.

Nationally, there are more than 240 ECHSs, in 28 states. North Carolina, with its strong community college and state university systems, is home to more than 70, which is approximately 30% of all ECHSs in the nation, and more than any other state. Figure 1 shows that about two thirds of North Carolina counties have an ECHS and that these schools are spread across all regions of the state. ECHSs have proliferated primarily under the auspices of North Carolina New Schools (NCNS), which was established in 2003 to accelerate systemic, sustainable innovation in North Carolina schools. ECHSs receive approximately $11 million annually from the North Carolina General Assembly. NCNS-guided ECHSs in North Carolina implement a core set of design principles: college readiness, powerful teaching and learning, personalization, redefined professionalism, leadership, and purposeful design (Edmunds, Willse, et al. 2013).

Edmunds, Willse, et al. (2013) theorize that part of the success of ECHSs stems from a school culture of "mandated engagement," which informs relationships among students, among teachers, and between students and teachers and staff. Students report that unlike in traditional public high schools, disengagement is made much harder in ECHSs. Small schools of choice for both students and teachers designed around a shared mission and constituted as new schools, ECHSs raise academic rigor by enrolling students in college-level courses in freshman year. To help students meet these higher expectations, ECHSs are staffed with teachers, counselors, and administrators who understand that personalization and academic support are critical for student and organizational success.

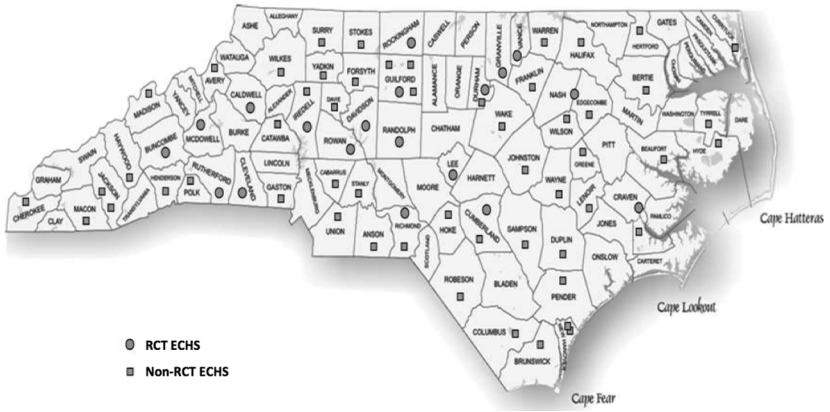

FIG. 1.—RCT and non-RCT early college high schools (ECHSs) in North Carolina. RCT sites are those early colleges that have at least one cohort in the ongoing RCT study by Edmunds et al. Non-RCT sites are those early colleges that have no cohorts in the study by Edmunds et al.

Case studies and survey research provide a taste of the unique organizational culture of ECHSs. They highlight caring relationships, support, academic identity, and high expectations (Kaniuka and Vickers 2010; McDonald and Farrell 2012; Thompson and Ongaga 2011). Students report that they felt prepared for postsecondary education, valued relationships with teachers, and benefited from the small learning communities (Edmunds et al. 2010, 2012; McDonald and Farrell 2012; Thompson and Ongaga 2011; Woodcock and Olson Beal 2013). Survey analysis reveals that relative to students in traditional public high schools, ECHS students reported statistically significantly higher levels of expectations, more rigorous and relevant instruction, better staff–student relationships, and more frequent and varied types of support. Effect sizes ranged from 0.37 to 1.07, computed on mean differences in survey responses between students who entered an ECHS lottery and those who were randomly assigned to treatment and control groups (Edmunds, Willse, et al. 2013).

Experimental Evidence on the Effectiveness of the ECHS Intervention

To date, the best evidence on ECHS impacts comes from two RCTs, one retrospective and one prospective. A retrospective national study of ECHSs

identified 123 eligible ECHSs open in the fall of 2007 with at least one cohort of graduating students in the 2010–11 school year or earlier. Of these, only 20 held lotteries and only 10 had retained lottery records (Berger et al. 2013). This study reports significant impacts on high school graduation and college enrollment of 5 and 9 percentage points, respectively, and very large impacts on college degree attainment, which was typically an associate's degree. One in five ECHS students earned an associate's degree by the time he or she graduated from high school. ECHS impacts generally did not differ by student subgroup.

The other RCT is an ongoing prospective study covering 19 schools in North Carolina. In this long-term longitudinal experimental evaluation, students applied to study schools through lotteries. These lotteries randomly divided applicants into two groups: those offered the admission (treatment group), and those denied admission (control group). The study has been following students from these 19 ECHSs in North Carolina through high school and into college. Papers published on the earliest cohorts in six schools report significant improvements in retention, suspension, attendance, advanced course taking, graduation, college enrollment, and college degree attainment (Edmunds et al. 2010, 2012; Edmunds, Unlu, et al. 2013; Edmunds, Willse, et al. 2013). Results suggest a decrease in test pass rates for some courses, but lower scores may be related to ECHS students taking advanced courses earlier and more frequently (Edmunds et al. 2010).

Contribution of the Present Study

Current research on ECHSs is either based on interviews or surveys or is experimental. Qualitative work is beneficial to understanding the mechanisms of the intervention, but this work has relied on small samples of students who voluntarily chose to participate and may not be a representative group. Although it has produced estimates with very strong internal validity, the RCT evidence published thus far suffers from limited external validity because it is based on only a small number of oversubscribed schools willing and able to hold lotteries. The concern is that oversubscribed ECHSs willing to hold lotteries may differ in important ways from more typical ECHSs. For example, figure 1 shows that there are very few RCT sites in the eastern part of the state, a heavily African American region. If effects vary by region, then generalizability of RCT impacts to the statewide population of ECHSs will be more limited. In addition, the small sample size of the RCTs limits the abilities of these studies to assess the heterogeneity of impacts across subgroups of students and locales in the state.

This study contributes to the generalizability of experimental ECHS impacts by addressing two research questions using data on all ECHSs in North Carolina:

1. What is the ECHS impact on important secondary and postsecondary enrollment and completion outcomes?
2. Do ECHS impacts vary by student subgroup, district average achievement, and host-campus type?

The next section describes the data and the QE design methods we use, and the strong warrant for internal validity of these methods in the methodological literature on the effects of educational interventions in authentic settings.

Data and Method

Sample and Outcomes

To examine the relationship between attending an ECHS and students' secondary and postsecondary outcomes, this study uses student- and school-level data from various sources. The North Carolina Department of Public Instruction (NCDPI) provided student-level data on all high school students in North Carolina from 2004–5 through 2011–12. These data were matched longitudinally for individual students. This data set provides secondary school outcomes including standardized test scores, student absences, ninth-grade retention, and graduation information. In addition to outcome measures, the data include the following control variables: eighth-grade math and reading achievement, student ethnicity, free or reduced-price lunch status, academically or intellectually gifted (AIG) status, limited English proficiency (LEP) status, disability status, days absent, and parental education. The primary data set provided by NCDPI was combined with additional data from the University of North Carolina General Administration and the North Carolina Community College System from 2008–9 through 2011–12. These data sets supply postsecondary outcomes including enrollment in community college or UNC system 4-year colleges, associate's degree completion, and selectivity of 4-year college. It is important to note that the postsecondary data are somewhat limited in that they include information only on North Carolina's public institutions and do not account for in-state private institutions or out-of-state public and private institutions. Recent national estimates indicate that about 75% of high school college-going graduates enroll in an in-state public institution (Hemelt and Marcotte 2016), so we are likely capturing the bulk of college enrollments, but not all of them.

The numbers of cohorts, students, and ECHS schools included in the regressions vary by outcome because the most recent cohorts cannot yet be included in analyses of the longer range outcomes such as graduation from high school or postsecondary completion (see online app. A for the number of sites and cohorts included in each analysis). Data about retention in ninth grade, absences, and test scores are from the 2005–06 to 2010–11 ninth-grade cohorts. Data about 5-year graduation and community college enrollment are from the 2005–06 to 2007–08 ninth-grade cohorts. Data about having an associate's degree 2 years out and UNC system (4-year university enrollment) are from the 2005–6 and 2006–7 ninth-grade cohorts. Data about having an associate's 3 years out is from only the 2005–6 ninth-grade cohort. For eligible cohorts, community college enrollment is coded as 1 if the student enrolled in any of the North Carolina Community Colleges by the spring semester of 2012 and as 0 if he or she had not done so. Students who were concurrently enrolled in a high school (including an ECHS) are not included in community-college enrollment analyses. A student in an eligible cohort is coded with a 1 for associate's degree completion 2 or 3 years out if the student received an associate's degree from any community college by the end of the spring semester 2 or 3 years after target on-time high school graduation year (i.e., 6 or 7 years after high school entry year). For eligible cohorts, a student is coded as having enrolled in the UNC system if he or she attended a UNC system campus at any time between high school graduation and the spring semester of 2012. None of our postsecondary outcomes are conditional on high school graduation.

Selection Concerns

Because ECHSs in North Carolina are schools of choice, students who choose to attend them may be different from students who do not choose to enroll. ECHS students may be different in their family backgrounds, their previous academic achievement, and their motivation. Some of these differences are directly observable by comparing ECHS students to their peers in other schools in the districts that feed into the ECHSs. Table 1 shows the demographics, eighth-grade performance, and special program participation for students who choose to attend an ECHS and these same characteristics for students in comparison districts in the 2005–06 to 2011–12 ninth-grade cohorts. For most ECHSs, the comparison district is simply the district in which the ECHS is located. However, some ECHSs serve multiple districts, in which case all districts that are served by the specific ECHS are included in the sample as comparison districts.

Table 1 shows some small, but statistically significant, sociodemographic differences between students who attend ECHSs and other students in the districts

TABLE 1

Demographics and Prior Performance of Ninth-Grade Cohorts in Early College High Schools, 2006–2012

	Early Colleges	Comparison Districts	Mean Within-District Difference	*p*-Value of Difference
n	62	75		
White (%)	68.4	68.3	.2	.956
Black (%)	24.1	28.7	−4.6	.272
Hispanic (%)	10.7	6.7	4.1	.001***
Asian (%)	2.2	1.0	1.3	.012*
Other (%)	4.4	4.0	.4	.700
Parents less than high school (%)	6.3	8.0	−1.7	.034*
Parents high school graduates (%)	42.1	44.1	−2.0	.368
Parents some college (%)	25.3	21.9	3.4	.007**
Parents college graduates (%)	19.0	21.5	−2.5	.123
Free lunch (%)	39.8	39.1	.7	.715
Reduced-price lunch (%)	11.7	9.1	2.6	.000***
Current LEP (%)	3.8	3.3	.5	.344
Formerly LEP (%)	3.0	1.2	1.8	.000***
Disability (%)	4.3	10.3	−5.9	.000***
Gifted (%)	20.1	14.6	5.5	.000***
Eighth-grade math	.328	−.073	.435	.000***
Eighth-grade reading	.362	−.073	.401	.000***
Algebra I in eighth grade (%)	28.0	18.4	9.6	.000***
Eighth-grade absences	7.126	8.25	−1.123	.000***

NOTE.—The number of comparison districts is larger than the number of early colleges because some early colleges serve more than one district.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

that feed these schools. ECHS students are more likely to be Hispanic or Asian, to have parents who attended some college (but did not attain a bachelor's degree), and to receive reduced-priced lunch but are less likely to have parents who did not graduate from high school. More striking, however, are the differences in prior school performance between ECHS students and other students in the comparison districts. ECHS students are more likely to be identified as gifted and to have eighth-grade test scores about 0.40 standard deviations higher than comparison students and are about 10 percentage points more likely to have taken Algebra I in eighth grade. In addition, ECHS students have fewer absences and are less likely to have an identified disability.

Given these measureable differences in the prior performance of students who select to attend ECHSs compared with their district peers, we would ex-

pect that ECHS students would have better secondary and postsecondary academic outcomes than other students in their districts. Therefore, to avoid producing biased impacts, we use a strategy to select appropriate comparison groups of students who, prior to entry into high school, had similar academic outcomes to the students who attended ECHSs. We rely on propensity score matching to create these comparison groups, a method that under certain conditions can produce impacts with high internal validity. We now turn to a discussion of these key conditions.

Under What Conditions Can Quasiexperimental Methods Produce Credible Program Impacts?

RCTs are the gold standard because successful randomization ensures baseline equivalence on both observable and unobservable confounds. Well-designed WSCs have demonstrated that under certain conditions, QE designs that match treatment units from RCTs with nontreatment units that did not participate in random assignment can produce impacts that closely correspond to the experimental impacts, thus implying a degree of internal validity that is as high in practice as in the RCTs. Prospective WSC studies were designed to validate specific QE practices and have shown proof of concept: high-quality educational experiments and well-designed quasiexperiments generate quite close causal estimates (Aiken et al. 1998; Shadish et al. 2008). Two of the most important conditions are that matching should be local (the comparison cases drawn from same setting as the treatment cases) and also focal (the covariates should include those believed to predict both selection into treatment and the outcome, of which pretest measures of the outcome at one or more times are especially important; Bifulco 2012; St. Clair et al. 2014; Steiner et al. 2011).

Earlier WSC studies in education reported less correspondence in RCT and QE causal impacts (Agodini and Dynarski 2004; Wilde and Hollister 2007). But, analysis in Cook et al. (2008) shows that they involved either failed RCTs with initial imbalance between the treatment and control groups, nonlocal matches with little initial overlap, few covariates associated with selection and no or poor pretest measures of the outcome, extremely small sample sizes that led to imbalance and low power in propensity score analyses, or some combination of these shortfalls. The quality of WSC studies is now much higher than was evident in these early pioneering studies in education.

More recent and better-designed WSCs, all conducted retrospectively and in authentic educational settings, report very similar experimental and QE impacts on test-score outcomes. For example, Bifulco (2012) measured the bias produced by a dozen QE approaches using an experimental study of the impact of attendance in a magnet school on children's reading performance. This

work suggests that the pool from which comparison units are drawn for the QE design has a substantial impact on the accuracy of the replication. In this study, drawing comparison cases from the same districts or districts with similar student-body characteristics substantially reduced bias. When comparisons were drawn from districts with different student-body characteristics than the treatment students' districts, the addition of pretreatment test scores alone was substantially less successful in reducing differences between the experimental and nonexperimental approaches.

Abdulkadiroğlu et al. (2011) studied Boston charters and pilot schools and conducted a supplementary analysis comparing experimental and QE impacts, finding that experimental estimates were quite close to QE impacts and that schools holding lotteries generally had impacts much larger than schools not holding lotteries. Three national evaluations of charter schools by Mathematica have included substudies to validate QE models. All report successful validations and all included very similar QE models: focal covariates, including baseline test scores, and local matching from feeder elementary and middle schools (Fortson et al. 2012; Furgeson et al. 2012; Tuttle et al. 2013).

This literature clearly demonstrates that QE impacts on test-score outcomes from authentic educational settings can have high internal validity. The present study uses QE methods informed by this literature to estimate impacts on the largest sample of ECHSs to date.

Analytic Strategy

We use a doubly robust propensity-score-matching approach with 3 : 1 nearest-neighbor matching (without replacement) on highly local intact groups with pretests. Our propensity model estimates the probability of student i choosing to attend an ECHS in ninth grade in year t as a function of math and reading achievement, gender, student ethnicity, free or reduced-price lunch status, disability status, AIG status, LEP status, and number of days absent, all measured in eighth grade. Test scores, free or reduced-price lunch status, and being black or Hispanic are all strong positive predictors of enrollment in an ECHS. Being male, disability status, and days absent are negatively related to ECHS enrollment. Results of our propensity model are reported in online appendix B.

With the estimates from our propensity model, we construct propensity scores for a given student's probability of enrolling in an ECHS based on observable characteristics. We then use the student propensity scores to create a comparison group by matching the propensity scores of treated students to those of untreated students. In effect, this creates a reduced sample that includes both treatment and comparison students. Because there is significant overlap in the propensity scores between ECHS and non-ECHS students, the analysis uses

nearest-neighbor matching without replacement.[2] Smith and Todd (2005) and Imbens (2004) suggest that this method, in the presence of similar propensity distributions, provides for good matches while reducing the variance of the estimated treatment effect. Nearest-neighbor matching without replacement requires that all students are sorted by propensity score and then matches a treated student to the student with the closest propensity score. Because the distributions of the propensity scores are extremely similar, we match each treated student to the three nearest-neighbor untreated students (i.e., the three untreated students whose propensity scores are most similar to that particular treated student). Smith (1997) suggests that increasing the number of matches will reduce the variance of the estimated treatment effect at the cost of increased bias due to poorer matches. However, in the case of similar propensity distributions, the potential increase in bias is reduced. We estimated various propensity score models (1:1 and 3:1, with and without replacement, and with and without calipers). The results were quite similar across specifications; therefore, we present only results from one specification: 3:1 matching without replacement and with no caliper.

A key element of our research design is that we match students within middle school cohorts only by year. This addresses one of the most significant arguments against using propensity-score matching, which is that it cannot account for unobserved factors that influence the treatment choice. However, when matching within a well-defined intact group, such as students from the same neighborhood or middle school, the potential disparate influence of unobserved factors is reduced. Propensity-score matching with rich covariates, including pretests, and where comparison cases are matched to treatment cases from local intact groups is a design that, as outlined in the previous section, performs well in the methodological literature on WSCs (Cook et al. 2008). The estimates produced with this method can be considered causal if treatment assignment is strongly ignorable given the observable covariates in our propensity model. Finally, an examination of the balance of the unmatched and matched samples affirms that there are large differences between the treatment and comparison groups in many of the covariates before matching and that these differences are considerably reduced in all cases after matching (see online app. B).

We use linear probability models on the matched samples that were identified using propensity-score matching to estimate the effects of ECHSs on secondary and postsecondary outcomes of students who attend these schools. As stated, we use doubly robust estimation, which means we include the variables in the propensity model in the outcome regression on the matched sample. To account for any remaining differences between the treated students and the comparison students, the regressions include controls for demographic characteristics, pretreatment performance, and middle school fixed effects (Abadie and Imbens 2002; Imbens 2004).

Demographic controls are gender, ethnicity, participation in the school lunch program, and LEP status. Pretreatment performance controls are eighth-grade math and reading test scores, whether the student took Algebra I in eighth grade, gifted status, and disability status. For high school outcomes and associate's degree outcomes, we also control for the student's ninth-grade cohort. In addition, we control for the grade the student was in at the time of measurement when estimating the effect on the number of absences and the effect on end-of-course test scores.

We do not separately estimate and then average site impacts. Any student in an ECHS site gets a 1 as the ECHS treatment dummy variable; any other student gets a 0. The regressions on matched samples then average that treatment impact across all the available ECHS sites and cohorts in the regression for that particular outcome. The number of cohorts and of ECHS sites vary by outcome (see online app. A). Most outcomes are binary, so they can be interpreted as adjusted mean differences in probability between those who attended and those who did not attend an ECHS. We provide baseline means to interpret the size of the treatment comparison difference. Test-score outcomes are standardized.

To adjust for the fact that we are making multiple statistical comparisons, we use the Benjamini-Hochberg correction with a 5% false discovery rate (Benjamini and Hochberg 1995). Our tables note statistical significance with and without this correction. This effectively reduces our critical value from .05 to .03.

Results

We begin our summary of results with discussion of the effects on students overall, starting with impacts on high school outcomes, followed by postsecondary impacts. We then turn to differences in impact estimates by race, home-district performance, and host-campus location.

Overall Impacts

The top rows of table 2 show the effect of enrolling in an ECHS on secondary school outcomes for all ECHS students in our sample. Students attending ECHSs outperform comparable students attending regular district high schools for most of the secondary outcomes measured. ECHS students are less likely to be retained in ninth grade. Relative to matched comparison cases, they score higher on English I and Algebra I end-of-course tests, they have fewer absences, and they are more likely to graduate from high school within 5 years of starting. These results are in keeping with the positive outcomes found in previous

TABLE 2

Treatment Impact Estimates on Secondary School Outcomes for Ninth-Grade Cohorts in Early College High Schools, 2006–2012

	Ninth-Grade Retention	English I Score	Algebra I Score	Biology Score	Absences	5-Year Graduate
All students:	−.023*[a]	.086*[a]	.061*[a]	.043	−2.481*[a]	.020*[a]
	(.004)	(.009)	(.019)	(.034)	(.140)	(.009)
n	49,209	49,858	35,789	34,791	112,526	17,085
Baseline	.072	.294	.028	.220	8.135	.8095
Demographic subgroups:						
Black students:	−.030*[a]	.089*[a]	.063*[a]	.051	−2.402*[a]	.039*[a]
	(.007)	(.018)	(.020)	(.038)	(.182)	(.014)
n	13,001	13,420	10,489	9,297	31,043	4,605
Baseline	.114	−.123	−.307	−.263	8.582	.811
White students:	−.012*[a]	.084*[a]	.035	.046	−2.419*[a]	.006
	(.004)	(.010)	(.023)	(.036)	(.169)	(.011)
n	28,353	28,350	19,264	20,121	63,794	10,209
Baseline	.052	.552	.227	.459	7.831	.811
Home-district performance subgroups:						
Highest third of districts:	−.002	.074*[a]	−.065	.029	−2.419*[a]	.000
	(.007)	(.015)	(.034)	(.066)	(.201)	(.013)

n	16,320	16,489	11,836	11,448	37,021	5,861
Baseline	.060	.438	.200	.368	7.856	.829
Lowest third of districts:	−.040*[a]	.118*[a]	.092*[a]	−.030	−2.441*[a]	.036*[a]
	(.006)	(.017)	(.027)	(.037)	(.280)	(.016)
n	15,177	15,381	11,217	10,946	34,902	4,877
Baseline	.098	.122	−.156	.0313	8.507	.799
Campus location subgroups:						
2-year campuses:	−.019*[a]	.090*[a]	.057*[a]	.058	−2.531*[a]	.010
	(.004)	(.009)	(.020)	(.034)	(.147)	(.010)
n	43,217	43,845	32,452	33,311	106,432	14,208
Baseline	.069	.303	.054	.198	8.131	.814
4-year campuses:	−.051*[a]	.085*[a]	.177*[a]	.057	−2.671*[a]	.073*[a]
	(.010)	(.023)	(.026)	(.037)	(.171)	(.015)
n	6,056	6,475	6,998	30,760	68,598	2,942
Baseline	.098	.182	−.421	.145	8.659	.785

NOTE.—Districts are defined as being in the highest or lowest third of districts based on the average performance composite of all district high schools excluding early college high schools.

[a] Significant controlling for multiple comparisons using the Benjamini-Hochberg procedure with a false discovery rate of 5%.

* $p < .05$.

studies (Edmunds et al. 2010, 2012; Edmunds, Unlu, et al. 2013; Edmunds, Willse, et al. 2013).

Table 3 shows impacts on community college enrollment and completion. The top rows show that on average students attending ECHSs are slightly less likely to enroll in community college upon finishing high school but are much more likely to receive associate's degrees within 2 or 3 years of completing high school than their counterparts who attended regular district high schools. In particular, the increase in completion of associate's degrees in 2 years (22.5%) and 3 years (14.9%) is quite substantial considering that only 1% to 2% of comparison students attending regular district high schools complete these degrees within 2 or 3 years of finishing high school.

ECHS students are also more likely to enroll in the 4-year UNC system (table 4). The positive effect on 4-year enrollment is consistent with previous studies, although the magnitude of the effect may be somewhat smaller than impacts in prior work (Edmunds et al. 2010, 2012; Edmunds, Unlu, et al. 2013; Edmunds, Willse, et al. 2013). Prior studies have not reported impacts on enrollment by campus selectivity. We find that the positive impact on UNC enrollment overall is driven by positive impacts of attending an ECHS on two types of postsecondary institutions: noncompetitive and historically black colleges and universities (HBCUs).[3] The ECHS impact on enrolling in the state's two flagship universities, UNC Chapel Hill and NC State, is actually negative.

Impacts by Student Racial Background

The rows under the demographic subgroup heading of table 2 show the effect sizes for black and white students attending ECHSs compared with their counterparts in regular district high schools. In general, the effects appear similar across race, though in many cases the effect sizes are somewhat larger for black students compared with white students.[4] One notable exception is that black ECHS students are 4% more likely to graduate high school within 5 years than their counterparts attending traditional high schools; white ECHS students enjoy no graduation advantage compared with their comparison group.

Table 3 shows that attending an ECHS improves the likelihood of receiving an associate's degree within 2 or 3 years of graduating for both blacks and whites, but whites appear to benefit more from ECHS enrollment than blacks do. For example, the adjusted mean difference in the probability of an associate's degree 2 years out for whites who attended an ECHS versus whites who did not attend an ECHS is .272. The analogous adjusted mean difference for blacks is less than half as large at .116. For UNC system enrollment, this pattern is reversed. The ECHS impact on UNC enrollment is larger for black students than for white students (table 4). In fact, white ECHS students enjoy no

TABLE 3

Treatment-Effect Estimates on Community College Outcomes for Ninth-Grade Cohorts in Early College High Schools, 2006–2008

	Community College Enrollment	Associate 2 Years Out	Associate 3 Years Out
All early colleges:	−.011*	.225*[a]	.149*[a]
	(.005)	(.024)	(.028)
n	17,085	8,750	2,040
Baseline	.140	.008	.015
Demographic subgroups:			
Black students:	−.019	.116*[a]	.067*[a]
	(.013)	(.027)	(.027)
n	4,605	2,460	727
Baseline	.146	.001	.004
White students:	−.007	.272*[a]	.200*[a]
	(.006)	(.023)	(.032)
n	10,209	5,151	1,206
Baseline	.137	.013	.020
Home-district performance subgroups:			
Highest third of districts:	−.004	.264*[a]	.152*[a]
	(.010)	(.036)	(.010)
n	5,861	2,964	445
Baseline	.136	.011	.032
Lowest third of districts:	−.027*[a]	.196*[a]	.137*[a]
	(.011)	(.043)	(.046)
n	4,877	2,506	794
Baseline	.151	.003	.008
Campus location subgroups:			
2-year campuses:	−.015*	.279*[a]	.206*[a]
	(.006)	(.017)	(.023)
n	14,208	7,165	1,529
Baseline	.140	.010	.017
4-year campuses:	.008	−.004*	−.007
	(.013)	(.002)	(.005)
n	2,942	1,589	513
Baseline	.137	.003	.008

NOTE.—Districts are defined as being in the highest or lowest third of districts based on the average performance composite of all district high schools, excluding early college high schools.

[a] Significant controlling for multiple comparisons using the Benjamini-Hochberg procedure with a false discovery rate of 5%.

* $p < .05$.

TABLE 4

Treatment-Effect Estimates on UNC System Outcomes for Ninth-Grade Cohorts in Early College High Schools, 2006–2008

	UNC System Enrollment	Competitive UNC Enrollment	Noncompetitive UNC Enrollment	Flagship Enrollment	UNC System HBCU Enrollment
All early colleges:	.045*[a]	.018	.027	−.014*[a]	.032*
	(.018)	(.011)	(.015)	(.004)	(.015)
n	13,030	13,030	13,030	13,030	13,030
Baseline	.285	.189	.096	.069	.050
Demographic subgroups:					
Black students:	.078*[a]	.016	.062	.002	.062*
	(.033)	(.011)	(.031)	(.006)	(.031)
n	3,623	3,623	3,623	3,623	3,623
Baseline	.299	.086	.213	.025	.172
White students:	.008	.012	−.005	−.025*[a]	.007
	(.016)	(.015)	(.006)	(.005)	(.004)
n	7,770	7,770	7,770	7,770	7,770
Baseline	.299	.249	.050	.092	.003
Home-district performance subgroups:					
Highest third of districts:	.007	.020	−.013*	−.011*	−.004
	(.020)	(.020)	(.006)	(.006)	(.004)

n	4,570	4,570	4,570	4,570	4,570
Baseline	.301	.229	.073	.084	.030
Lowest third of districts:	.086	.013	.072	−.012	.073
	(.043)	(.016)	(.042)	(.007)	(.042)
n	3,675	3,675	3,675	3,675	3,675
Baseline	.279	.136	.143	.059	.085
Campus location subgroups:					
2-year campuses:	−.001	.011	−.012*[a]	−.017*[a]	−.004
	(.013)	(.012)	(.004)	(.004)	(.003)
n	10,794	10,794	10,794	10,794	10,794
Baseline	.270	.185	.085	.066	.039
4-year campuses:	.194*[a]	.038	.156*[a]	.005	.163*[a]
	(.032)	(.022)	(.042)	(.009)	(.042)
n	2,334	2,334	2,334	2,334	2,334
Baseline	.357	.205	.152	.081	.105

NOTE.—Districts are defined as being in the highest or lowest third of districts based on the average performance composite of all district high schools, excluding early college high schools. UNC system campuses considered competitive are Appalachian State University, NC State University, UNC Asheville, UNC Chapel Hill, UNC Charlotte, UNC Greensboro, UNC Wilmington, and Western Carolina University. UNC system campuses considered noncompetitive are East Carolina University, Elizabeth City State University, Fayetteville State University, NC Agricultural and Technical State University, NC Central University, UNC Pembroke, and Winston-Salem State University. UNC system HBCUs include Fayetteville State University, NC Agricultural and Technical State University, NC Central University, Winston-Salem State University, and Elizabeth City State University.

[a] Significant controlling for multiple comparisons using the Benjamini-Hochberg procedure with a false discovery rate of 5%.

* $p < .05$.

significantly positive increase in any category of UNC system enrollment (any, competitive, noncompetitive, flagship, or HBCU). White ECHS students are less likely to attend one of the two UNC system flagship universities than comparable white students from neighboring high schools. Relative to comparable black students in nearby high schools, black ECHS students are more likely to attend the UNC system overall, are no less likely to attend one of the more competitive colleges in the system, and are more likely to attend noncompetitive and HBCU institutions ($p = .05$ and $p = .051$, respectively). Thus, the positive impact we observe for the sample as a whole is apparently driven by the positive impact on black students attending less selective 4-year institutions. These differences may be differences in the benefit to the students themselves or in the benefits of attending ECHSs in districts with varying demographic compositions or of attending an ECHS housed in varying campus types, which are both conditioned by race, as we discuss in the following two sections.

Impacts by Home District Performance

The rows under the home-district performance subgroup heading of table 2 show the effect sizes of attending an ECHS compared with a regular district high school in the bottom- and top-performing tertiles of districts in the state. The effects for some secondary school outcomes are larger for students in districts with lower performance compared with districts with higher performance (retention, English I, Algebra I, and 5-year graduation[5]). Districts with higher performance at the regular district high schools show no statistically significant impact of attending an ECHS on ninth-grade retention, Algebra I scores, or 5-year graduation rates. These differences between districts suggest that students benefit the most from attending an ECHS in districts where the default high school alternatives are low performing.[6]

Tables 3 and 4 suggest that although all ECHS students are more likely to receive associate's degrees than their counterparts in the regular district high schools, those in lower performing districts have higher UNC system enrollment. Again, these results suggest that the benefits of attending an ECHS may depend in part on the alternative high school options in the district and, perhaps, the location of the ECHS campus.[7]

Impacts by Campus Host Location

Existing research on ECHS impacts is based on lottery samples from a subset of schools hosted by community colleges, which host most, but not all, of the ECHSs in North Carolina. Because the present study covers all ECHSs in

North Carolina, we are able to compare the impacts of ECHSs hosted at community colleges with those of ECHSs hosted at 4-year institutions. Currently, five 4-year colleges or universities host ECHSs. Of these five hosts, four are HBCUs.[8] Compared with students at 2-year-hosted ECHSs, students at 4-year-hosted ECHSs are less likely to be white or Hispanic but are more likely to be black, to have higher family poverty rates, and to have lower eighth-grade test scores (see online app. E). We should note that in most cases, the sample of treatment schools is skewed heavily toward community college hosts, which greatly outnumber 4-year hosts. For most outcomes, we are comparing the performance of 40 or more ECHSs hosted at community colleges to 5 ECHSs hosted at 4-year institutions.

The impacts of 2- and 4-year-hosted ECHS on many secondary outcomes are of similar size and sign, but two differ substantially. Effects on retention, English I, and Algebra I are quite similar, though the size of the effects are generally larger for the 4-year-hosted ECHSs. We report virtually no impact on 5-year graduation rate for 2-year-hosted campuses (0.01), but a more substantial positive impact on the same outcome for 4-year-hosted campuses (0.07).[9]

Tables 3 and 4 reveal that institutional context conditions postsecondary impacts. In short, sites on community college campuses have strong effects on community college degree completion and sites on 4-year campuses have strong effects on 4-year outcomes. Generally speaking, the impacts of community college sites on 4-year enrollment are close to zero, and the impacts of 4-year sites on community college enrollment and completion are also close to zero. ECHS students hosted on 2-year campuses are no more and no less likely to enroll in a UNC-system institution than comparison students from neighboring high schools. ECHS students hosted on a 4-year campus, however, are much more likely to enroll in a UNC-system school than their peers. The 2-year hosted ECHS impact on flagship enrollment is negative and significant, at −0.017. The positive impacts of 4-year-hosted ECHSs are much stronger for noncompetitive-institution enrollment and for HBCU enrollment than for competitive-institution enrollment.[10]

Conclusion

National statistics paint a rather dire picture of college and career readiness. ECHSs are a promising intervention aimed at increasing career and college readiness for students traditionally underrepresented in postsecondary institutions. Small schools of choice on the campuses of community colleges and some universities are designed to ease the transition of students who may face significant barriers to completing high school and entering college. Such schools' size and common mission promotes a culture of mandated engagement (Edmunds,

Willse, et al. 2013) with a demanding college-preparatory curriculum and the necessary supports to increase the chances of student success in coursework.

Existing research from two experimental studies, one prospective and one retrospective, provides evidence of positive impacts on many important student outcomes, including retention, suspension, attendance, advanced course taking, graduation, college enrollment, and college degree attainment (Berger et al. 2013; Edmunds et al. 2010, 2012; Edmunds, Unlu, et al. 2013). The strength of these experimental studies is their internal validity. Their weakness is external validity, given that experimental ECHS studies are based on small samples of schools willing and able to conduct a lottery. A contribution of the present study is to estimate impacts on all ECHSs in North Carolina, a state with more such schools than any other state in the United States. It also permits a comparison of impacts at ECHSs hosted at 2- and 4-year institutions, which, as we have seen, differ dramatically.

Although a complete assessment of the generalizability of experimental impacts is beyond the scope of this study, we find some evidence to suggest that impacts of lottery schools may be larger than impacts of the full set of schools. For example, Edmunds, Unlu, et al. (2013) report an increase in community college enrollment of approximately 18 percentage points based on a lottery sample of 716 students and 6 schools. The present study reports a small negative effect on community college enrollment based on a nonexperimental sample that includes 17,079 students and 44 ECHSs.

Consistent with experimental studies, we find that the ECHS intervention has had generally beneficial impacts on secondary outcomes, with reduced absences and ninth-grade retention rates, higher math and English end-of-course test scores, and slightly higher 5-year graduation rates. This intervention has had a very large effect on associate's degree completion. Within 6 years of beginning high school, the average comparison-group student has a probability of attaining an associate's degree of .008. The predicted probability for the average ECHS student is .225. Within 7 years of high school entry, the corresponding probabilities for comparison and ECHSs, respectively, are .015 and .149. To put these figures into context, consider that a recent report from the National Center for Education Statistics based on the 2011–12 Beginning Postsecondary Survey found that only 7% of first-time postsecondary students had completed an associate's degree from any institution within 3 years (Ifill et al. 2016). Our study reports a baseline probability for community college enrollment of .140 (table 3). If the national rate from BPS holds for North Carolina during the time period of our study, this translates to a baseline probability of associate's degree completion within 7 years of entering ninth grade of about .01 (.140 × .07), which is a bit higher than our estimate of .008, but fairly close to it.

We note that these predicted probabilities are not 1.0 or even greater than .5, which indicates that most ECHS graduates are not attaining an associate's degree within 3 years of graduating. This should not be interpreted as a failure of the intervention, because the goal of the intervention is either associate's degree completion or 2 years of accumulated college credit, and sites varied on whether they focused on the latter or the former. But, given the wage benefit enjoyed by associate's degree holders (Kane and Rouse 1995; Marcotte et al. 2005), a large impact on this outcome is impressive nonetheless. In future work, we plan to examine the effect of the intervention on college-credit accumulation while in high school. Unfortunately, data on this outcome was not available for this study.

The intervention has modest positive impacts on public in-state 4-year postsecondary institutions and small negative impacts on enrollment in the state's two flagship universities, UNC Chapel Hill and NC State. Our ability to fully assess the reasons for these differences is limited in the present study. Future research could examine differences in application and admittance rates and measure impacts on all postsecondary institutions, including private and out-of-state institutions. Less competitive colleges may be willing to award transfer credit for community college courses taken by early college students during high school, which may make these colleges more attractive to these students than colleges that award fewer transfer credits.

The small sample size from RCTs limits the abilities of these studies to assess the heterogeneity of impacts across subgroups of students and across locales in the state. With a much larger set of schools and students, we undertake an assessment of differential impacts. The positive impacts on English I end-of-course test scores and associate's degree completion and the negative impacts on absences are quite consistent across the student subgroups and locales examined in this study. On the other outcomes, impacts vary by subgroup. On some, but not all, outcomes, there is evidence of larger impacts for black students than whites. The impact on 5-year graduation rates is positive and significant for black students but essentially zero and statistically insignificant for white students, so it appears that the overall impact for all students is largely driven by the impacts on black students. The findings for postsecondary outcomes are somewhat different. We find larger positive impacts for white students on community college outcomes and larger positive impacts for blacks students on 4-year enrollment outcomes. In fact, for white students, there is no statistically detectable impact on 4-year enrollment (impact is 0.008); among blacks, this impact is fairly large and statistically significant (impact is 0.078) and represents about a 30% increase on the baseline probability of attending a 4-year institution of .29. As discussed, we report negative impacts on flagship enrollment. This appears to be driven by white students rather than by black

students, who are no less likely to enroll in such institutions. We report positive impacts on HBCU enrollment for black students.

Our study shows that effects depend in part on the location of the ECHS. This shows the importance of the counterfactual. The quality of the default alternatives appears to matter. Some secondary impacts are larger in lower performing districts than in higher performing districts. For example, the impact on the 5-year graduation rate in the lowest performing districts is 0.036 and statistically significant; in the highest performing districts, this impact is approximately zero and statistically insignificant.[11] Postsecondary impacts on any 4-year enrollment are small and statistically insignificant in the highest performing districts and much larger but statistically insignificant in the lowest performing districts. Impacts on flagship enrollment are negative, significant only for the higher performing districts, and roughly same size in these two types of districts. In addition, we report that the positive impact of ECHSs overall on community college completion is accounted for entirely by ECHS sites on community college campuses, and the positive impact of ECHSs overall on 4-year enrollment is almost entirely accounted for by the few sites on 4-year college and university campuses. This suggests the institutional ties—where a site is hosted—are particularly important in understanding the intervention's effects on postsecondary outcomes.

The findings of this study are encouraging given that most ECHSs in North Carolina are located in rural areas and that rural high schools on average send fewer students to postsecondary institutions than schools serving other disadvantaged groups (Byun et al. 2012). Perhaps the largest factor contributing to rural students' lower rates of postsecondary enrollment is low socioeconomic status (Adelman 2002). The low socioeconomic status of rural students can influence their decisions to attend a postsecondary institution in many ways, but there are two specific issues that the ECHS system addresses. First is the general concern that increasing tuition rates will become an even greater obstacle to college attendance for lower income families. The ECHS system helps to mitigate some of these concerns, as students receive college credit without paying tuition or course fees. Second, because most rural high school students' parents did not attend a postsecondary institution, rural students may have lower educational expectations and parental encouragement (Chenoweth and Galliher 2004). Furthermore, they may be less able to navigate the college application process. The ECHS system helps to provide higher expectations and encouragement by embedding college-level expectations within the curriculum, and it can also provide resources for navigating the college application process for those students wishing to continue their educational attainment.

Although the results in this article suggest that the ECHS model is a promising one, there are some important factors that may limit the generalizability of this intervention. First, the ECHSs in North Carolina are able to benefit from

a large, well-established system of community colleges, which are able to host ECHSs across the state. A state with a less extensive community college system would likely have more difficulty in spreading the ECHS intervention statewide. Second, the NCNS organization provided support to the ECHSs in the state. It is not clear whether the ECHS model would be implemented as effectively without a centralized support organization similar to NCNS. Given that this intermediary organization closed abruptly in 2016, it is also not yet clear whether this leadership and instructional support will be maintained by some other entity. Finally, the ECHSs in North Carolina are schools of choice serving students who tend to outperform their peers prior to entry. Although the ECHSs in this study appear to be successful with the students they attract, we cannot conclude that they would be equally successful with students who were not attending by choice or who were less academically prepared prior to entering high school.

In closing, this study has shown that the ECHS intervention is generally quite successful at increasing high school outcomes, greatly boosts associate's degree completion, and increases 4-year-college enrollment at less selective public institutions. We also show many differences in these impacts across race, the performance of the home district, and the host site, which help us better understand the implementation and effects of this promising intervention in one of the few states that has brought this school reform model to scale.

Notes

1. A "within-study design replication," also known as a "within-study comparison," compares the effect from an experiment with the effect from a quasiexperimental study sharing the same treatment group (Cook et al. 2008).

2. Online appendix C shows a great deal of overlap in the distributions of the propensity scores of ECHS students and non-ECHS students before matching. This means that propensity-score matching is likely to be quite successful in finding comparison cases for treatment cases. After matching, these distributions are virtually identical. Note that the probability of attending an ECHS is a rare event because ECHSs are small schools, and there are many public school students in the denominator. Across all cohorts, the marginal probability of attending an ECHS is 0.024. For individual cohorts, this probability ranges from 0.005 to 0.031.

3. UNC system campuses considered by *Barron's* selectivity ratings to be competitive are Appalachian State University, NC State University, UNC Asheville, UNC Chapel Hill, UNC Charlotte, UNC Greensboro, UNC Wilmington, and Western Carolina University. UNC system campuses considered noncompetitive are East Carolina University, Elizabeth City State University, Fayetteville State University, NC Agricultural and Technical State University, NC Central University, UNC-Pembroke, and Winston-Salem State University. UNC system HBCUs include Fayetteville State Uni-

versity, NC Agricultural and Technical State University, NC Central University, Winston-Salem State University, and Elizabeth City State University.

4. The effect of ECHS enrollment is significantly different between black and white students on two outcomes: ninth-grade retention and 5-year graduation (see online app. D).

5. Difference between district types in 5-year graduation significant at $p < .10$.

6. Differences between district types in biology and absences are nonsignificant at $p < .05$. Difference in graduation rate is significant at $p < .10$ (see online app. D).

7. Community college enrollment and noncompetitive UNC enrollment differences are significant at $p < .05$. All other differences have $p \geq .05$.

8. ECHSs at four HBCUs (Fayetteville State, NC Agricultural and Technical State, NC Central, and Bennett College) were open prior to 2005–06. One more, at UNC Wilmington, opened in 2006–07.

9. All differences in host type are significant at $p < .05$, except English I and absences.

10. All differences in host type are significant at $p < .05$, except competitive UNC enrollment.

11. The p-value of this subgroup comparison is only marginally significant ($p = .078$).

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