Remedial Enrollment During the 1st Year of College, Institutional Transfer, and Degree Attainment

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ABSTRACT

This study examined whether remediation enrollment during the 1st year of college influenced individuals’ college transfer and attainment and if effects varied by racial and socioeconomic subgroups. Results based on analysis of the National Longitudinal Survey of Youth of 1997 data indicated that for 2-year college students, remediation enrollment in both mathematics and English improved the likelihood of transferring to a 4-year college and earning a bachelor’s degree. For 4-year college students, however, enrolling in any postsecondary remediation—only math, only English, or both subjects—during their 1st year in college increased their chances of transferring to a 2-year college in the following years. Enrolling in at least 1 math remedial class (i.e., only math and both subjects) appeared to hinder 4-year college students from graduating on time. Subgroup analyses showed no strong evidence that remediation enrollment played a significant role in increasing or reducing the racial and socioeconomic gaps in college attainment.

Each year, many students enter postsecondary institutions academically underprepared with respect to their numeracy and literacy skills (Parsad, Lewis, & Greene, 2003; Sparks & Malkus, 2013). Recent national statistics have indicated that nearly half of undergraduates while enrolled in a 2- or 4-year college will take at least one remedial course in mathematics or English (Chen, 2016; Radford & Horn, 2012). Remedial education in college is now a growing concern among educators and policymakers as it costs an estimated $5.6 billion to $7.0 billion a year nationwide (Alliance for Excellent Education, 2011; Scott-Clayton, Crosta, & Belfield, 2014). With so many students and enormous resources involved, the question is whether postsecondary remediation increases the likelihood that students will persist and graduate.

Remediation was initially established to increase college access and success for those academically ill-prepared students who otherwise would have stopped after high school (Day & McCabe, 1997; Rouche & Rouche, 2003; Sparks & Malkus, 2013). Recent national statistics have indicated that nearly half of undergraduates while enrolled in a 2- or 4-year college will take at least one remedial course in mathematics or English (Chen, 2016; Radford & Horn, 2012). Remedial education in college is now a growing concern among educators and policymakers as it costs an estimated $5.6 billion to $7.0 billion a year nationwide (Alliance for Excellent Education, 2011; Scott-Clayton, Crosta, & Belfield, 2014). With so many students and enormous resources involved, the question is whether postsecondary remediation increases the likelihood that students will persist and graduate.
Statistics have consistently shown that students who are low-income, Black, and Hispanic are disproportionately enrolled in remediation programs across higher education institutions (Adelman, 2004; Chen, 2016; Radford & Horn, 2012). Although the benefits of remediation remain unclear, some scholars have argued that such practices, instead of mitigating differences in college preparation, act as an institutional mechanism for resorting and “cooling out” low-performing disadvantaged students (Bettinger & Long, 2004; Deil-Amen & Rosenbaum, 2002). The next question, then, is whether remediation has a differential effect for socially and economically advantaged and disadvantaged student groups.

A growing body of research has assessed the effects of remediation enrollment on a variety of college outcomes (e.g., credits earned, persistence, and graduation) and has produced results that were mixed (see a recent meta-analytic review by Valentine, Konstantopoulos, & Goldrick-Rab, 2017). Although some studies revealed that remediation had a positive but modest impact for 2-year college students (Moss & Yeaton, 2013; Moss, Yeaton, & Lloyd, 2014), the others showed an effect that was neutral or negative (Clotfelter, Ladd, Muschkin, & Vigdor, 2015; Martorell & McFarlin, 2011). Similarly, inconsistent estimates were observed for remediation among 4-year college students (Attewell, Lavin, Domina, & Levey, 2006; Bettinger & Long, 2009; Martorell & McFarlin, 2011). In addition to conflicting findings, these previous studies were subject to two important conceptual and methodological limitations. Most researchers focused only on estimating the independent effect of remediation for different remedial subjects (e.g., math, reading, or writing) separately. These subject-specific studies failed to recognize the fact that a sizeable number of undergraduates are exposed to multiple subjects at the same time (Bahr, 2007, 2010; Parsad et al., 2003). Moreover, with the exception of the study by Attewell et al. (2006) that used a nationally representative sample, all previous studies analyzed student data from a single institution or state, which had limited external validity.

This study extended the literature on postsecondary remediation enrollment in three ways. First, unlike previous studies that have been overwhelmingly subject-specific analyses, in this study, students were categorized into different “remedial treatment groups” that separated students enrolling in a single remedial subject (i.e., math or English) from those enrolling in both remedial subjects (i.e., both math and English). Second, effects of single-subject remediation and dual-subject remediation were tested with a nationally generalizable sample of a recent cohort of college students from 2-year and 4-year institutions, which allowed for greater generalizability. Third, a propensity score-based technique with stratification and inverse probability weighting, which is a new methodological approach
in remediation research, was used to estimate the remediation effects while controlling for potential selection bias.

**Background**

**How might postsecondary remediation help or hinder student success?**

Remediation is perhaps the most common, large-scale intervention that postsecondary institutions use to address academic deficiencies among college students with poor preparation. In recent literature, there have been three major arguments as to how postsecondary remediation can influence student college pathways and outcomes in different ways. The first argument, a positive view of remediation, is that postsecondary remedial education, often called “developmental education,” should help students to foster or strengthen their skills in certain academic areas (e.g., math, reading, and writing) that are critical for success in college (Bettinger, Boatman, & Long, 2013). The benefits of remediation therefore should include an increased probability of college persistence and completion. This positive developmental effect, however, may be weaker for those students who enrolled in but did not complete a remedial course as they would only receive partial treatment and thus limited benefits of remediation (Bettinger & Long, 2004; Chen, 2016).

The second perspective argues that remediation could negatively affect students in unintended ways. Failing a placement test upon entering college and being assigned to a remedial course can send a signal to the students that they are not “college material” (Clotfelter et al., 2015; Deli-Amen & Rosenbaum, 2002; Scott-Clayton & Rodriguez, 2015). Such a stigma may discourage students from continuing their postsecondary studies as they might view themselves as inadequate and feel they are not succeeding, not up to the task, and subsequently may not do well in college. This stigma is likely to be more pronounced for remedial students attending a selective college where a larger proportion of their peers are not involved in any remedial programs (Bettinger & Long, 2004; Deli-Amen & Rosenbaum, 2002).

The third view of remediation suggests that enrolling in remedial classes may have a disrupting effect on course taking, regardless of its impact on student learning or performance. For the vast majority of higher education institutions, it is a common practice that academically underprepared students are required to take and pass noncredit remedial courses prior to taking college-level coursework (Parsad et al., 2003). Students with greater academic deficiencies may even take more than one or two semesters of remedial courses to meet the prerequisite requirements (Bahr, 2013; Bailey, Jeong, & Cho, 2010; Parsad et al., 2003). This particular enrollment
restriction is likely to disrupt course-taking patterns and impose extra financial burdens on remedial students in college, especially those students who need to take courses in multiple remedial subjects. If the disruption effect is large, the remediated students are expected to take more semesters or years to graduate or to be less likely to obtain a degree compared with their nonremediated peers (Scott-Clayton & Rodriguez, 2015).

How might postsecondary remediation affect students differently?

One consistent finding in educational statistics has been that low socio-economic-status (SES) and minority students account for a larger share of enrollment in postsecondary remediation (Adelman, 2004; Sparks & Malkus, 2013). Hence, it is important to recognize that heterogeneity among remedial students based on race and SES may interact with remediation to produce differential effects on college outcomes. A growing body of sociological literature has shown that racial and ethnic minorities in postsecondary institutions could suffer from stereotype threat, a situation in which negative-ability stereotypes increase their cognitive psychological load and reduce their academic effort (Massey & Fischer, 2005; Owens & Lynch, 2012; Steele & Aronson, 1995). Therefore, participating in a remedial class is likely to trigger the stereotype threat effect among minority students as they are exposed to the signal of being a member of low-achieving groups in colleges. According to the stereotype threat perspective, one would expect to find that remediation affects Black and Hispanic students more negatively. The negative effect of stereotype threat could be stronger in selective or 4-year colleges that enroll predominantly White students, but it might not be the case in less selective or 2-year colleges.

Similar to racial minority groups, low-SES students tend to be low-achieving and underrepresented on higher education campuses (Schneider & Saw, 2016). Yet they are overrepresented in remedial classes. It is likely that students whose parents had no college education may experience negative effects from enrolling in remediation to a greater extent compared with their counterparts whose parents had some college education. Previous research has documented that college students whose parents had no college experiences struggle to adjust to new cultures or learning styles in the higher education environment, which are more closely aligned with the cultural capital and academic experience possessed by students whose parents attended college (e.g., Armstrong & Hamilton, 2013; London, 1989; Pascarella, Pierson, Wolniak, & Terenzini, 2004). Lacking a sense of belonging, as has been shown, can undermine not only subjective well-being but also intellectual performance in college (Walton & Cohen, 2007, 2011). From this perspective, remedial students
whose parents had no college education are likely at greater risk for dropping out of college, and being placed in a remedial class may evoke and exaggerate the feeling of uncertainty about their belonging in post-secondary institutions.

**Previous evidence on postsecondary remediation enrollment**

Several empirical studies have sought to estimate the impact of postsecondary remediation enrollment by employing experimental and quasiexperimental designs. The only previous study with random assignment\(^3\) that sampled students from a 2-year college revealed modest positive effects of math remediation on grades in college-level math courses (Moss et al., 2014). Although the experimental research provided credible causal estimates, the findings were not generalizable across various institutions and demographic backgrounds. Moreover, this study not provide evidence on longer-term college outcomes such as institutional transfer or degree attainment.

A number of researchers have used statewide administrative data with quasiexperimental longitudinal designs to test remediation effects (Valentine et al., 2017). The empirical results for 2-year college student samples from different states have been mostly mixed. For instance, Bettinger and Long (2005) and Calcagno and Long (2008) documented that enrollment in a remedial math course at 2-year colleges in Ohio and Florida increased the number of earned credits and the probability of persistence and transferring to a 4-year college. However, the positive effect was not found for English remediation or when examining long-term attainment outcomes such as degree completion. In contrast, Clotfelter et al. (2015) found that in North Carolina, remediation enrollment in either math or English in 2-year colleges significantly decreased the likelihood of passing a college-level math or English course and obtaining a degree or diploma.

The available findings on remediation effects for 4-year college students from different states have also been inconsistent. Drawing on statewide 4-year college data from Ohio, Bettinger and Long (2009) found that remediation enrollment in either math or English significantly increased the probability of persistence, not transferring to a 2-year college, and degree receipt. However, Boatman and Long (2010) analyzed 2-year and 4-year college student data from Tennessee and reported that remediation in math, reading, or writing generally had a negative effect on total credits completed, persistence, and graduation. In another study using statewide data from Texas, which included both 2-year and 4-year college student samples, Martorell and McFarlin (2011) found that enrolling in a math or English remedial class had no impact on earned credits, transfer behavior, or degree completion.

Most previous studies have tended to analyze student data from a single institution or state. Although the results are relevant in evaluating specific
remediation programs or policies at the local level, they may not be generalizable to other parts of the country. There is a scarcity of research on postsecondary remediation effects based on a nationally representative sample. The only available study was conducted by Attewell et al. (2006), who used data from the National Education Longitudinal Study of 1988 (NELS:88). This study also revealed mixed results of the effects of remediation in math and English on degree completion for both 2-year and four-year college students. Despite informative findings, Attewell et al.’s study suffered from two important methodological limitations. First, remediation variables in NELS were created based on participants’ transcripts throughout their entire postsecondary careers, thus making it impossible to determine the timing of remediation enrollment (e.g., during the first semester or year). As a result, Attewell et al. focused only on exploring how remediation predicts any degree completion 8.5 years after a student leaves high school. Second, due to the matching approach employed in the study, the final matched samples across different estimation models ranged from as low as 8% to about 53% of the original defined study population (12 of 20 models used less than one third of the student sample). Thus, the generalizability of their results is difficult to gauge.

Research to date has primarily focused on estimating the effects of enrollment in a specific remedial subject (e.g., math, reading, or writing). Subject-focused analysis works best for evaluating subject-specific domain outcomes such as cognitive improvement or passing a college-level course in a given subject area. However, when considering attainment outcomes such as college transfer and completion, subject-focused estimates provide limited insight as many students take multiple remedial subjects. The joint effect of multisubject remediation may not simply be the sum of the estimates on each remedial subject. Moreover, as demonstrated in Bahr (2007), the effect of a remedial subject such as math is likely to be interacting with the effect of another remedial subject such as English. Bahr’s (2007) study focused on community college students from one state, and it only offered evidence on the joint effect of multisubject remediation on the completion of remediation, not including any long-term educational attainment outcomes. This present study improved on previous work by analyzing a recent national cohort of students from both 2-year and 4-year colleges to examine the outcomes of students enrolling in a single remedial subject (i.e., math or English) as well as in both remedial subjects (i.e., math and English).
Methodological approach

Data and sample

A systematic examination of remediation enrollment effects requires detailed information on students’ course taking, background, and college experiences. This study drew from data from the National Longitudinal Survey of Youth of 1997 (NLSY97), which included a U.S. nationally representative sample of 8,984 individuals (including 6,748 respondents in the cross-sectional sample and 2,236 respondents in the minority supplemental sample), who were aged 12 years to 16 years old as of December 31, 1996, and were then aged 27 years to 31 years old in 2011. The NLSY97 survey served the purposes of the present study well because it contains postsecondary transcript data with term-by-term and course-by-course records in regard to college enrollment, course taking, and completion for respondents who reported attendance in a postsecondary degree program during any of the annual interviews from 1997 to 2011 (Rounds 1–15).

This study focused on estimating the effects of remediation enrollment in the 1st year of students’ college careers as it is the period in which most academically underprepared students are required or choose to take remedial courses. To construct an analysis sample for this study, a number of restrictions were imposed on the data. First, this analysis focused only on the individuals whose postsecondary transcript data were available. These individuals accounted for 3,818 of the original sample in the NLSY97. Second, the analytic sample was limited to those NLSY97 participants who started their postsecondary schooling career in either a 2-year or 4-year college and had valid information on their postsecondary enrollment status and coursework (deleting 6.7% of students from the baseline transcript data). Third, the analytic sample excluded students who only enrolled in any remedial courses after their 1st year in college (further deleting 12.2%). In doing so, those late-enrolled remedial students were not counted as nonremedial students—the reference group in this study. The remaining sample included 3,129 students. Among them, 1,474 individuals were first-time college students in a 2-year college and 1,655 individuals were first-time college students in a 4-year college.

Measures

In this study, students were grouped into distinct remediation enrollment categories, while taking into account the subject type of remedial courses in which they were enrolled during their 1st year of college. By using individuals’ course-level information recorded in the transcript data, remedial courses were identified using the 2010 College Course Map (CCM), which provides a taxonomy system for classifying postsecondary classes. All
students in the sample were further classified into four “remedial treatment groups”: (a) only-math remediation, (b) only-English remediation, (c) both-subject remediation (students who enrolled in both math and English remedial courses), and (d) no remediation (as a comparison group).

The dependent variables for this study were student outcomes, as measured by transfer between 2-year and 4-year institutions, and degree receipt. As shown in previous studies (e.g., Attewell et al., 2006; Martorell & McFarlin, 2011), not only is the type of educational outcome important in understanding the impact of postsecondary remediation, but of equal importance is the timing of attaining these outcomes (e.g., on-time or delayed graduation), especially for identifying the potential disruption effect of remediation. In this analysis, detailed chronological, term-level information about students’ enrollment across postsecondary institutions and degree completion as reported in the transcript data was used to create a series of time-relevant college outcomes. The first set of outcomes focused on institutional transfer between 2-year and 4-year colleges. For 2-year college students, the positive transfer outcomes included (a) transferred upward in the 2nd year and (b) transferred upward in the 3rd year; for 4-year college students, reverse transfer was regarded as a negative transfer outcome and included (a) transferred downward in the 2nd year and (b) transferred downward in the 3rd year. The second set of outcomes on degree completion included: for 2-year college students, (a) earned an associate degree (AA) within 3 years, (b) earned an AA within 4 years, (c) earned a bachelor’s degree (BA) within 6 years, and (d) earned a BA within 8 years; and for 4-year college students, (a) earned a BA within 4 years, (b) earned a BA within 6 years, and (c) earned a BA within 8 years.\(^5\)

As suggested in the literature, postsecondary remediation effects can largely be explained by student backgrounds, academic preparation, and institutional characteristics (Bettinger et al., 2013). To effectively capture the selection process into postsecondary remediation in math and English, this study included an extensive set of individual and contextual covariates (Online Appendix Table A1 presents the descriptive statistics of covariates). Several important individual and demographic characteristics were: gender, race/ethnicity, cognitive score, parents’ highest education, poverty level, intact family status, mother’s age at first birth, census region of residence when aged 16 years, and age when starting college. This analysis also drew on a collection of precollege and college measures with respect to high school academic preparation (including school sector, academic program, gifted education, math pipeline, science pipeline, total earned academic credits, overall grade point average [GPA], math GPA, and English GPA), precollege schooling experience (including late for school, absent from school, retention, percentage of peers who cut classes or school, and percentage of peers who planned to go to college), and postsecondary attendance (including on-
Table 1 presents descriptive statistics of key variables by postsecondary remediation status during students’ first year in a postsecondary degree program for 2-year and 4-year college students separately. In the final analytic sample of this study, as expected, rates of any remediation during the 1st year in college among 2-year college students were higher than those among 4-year college peers (77.3% vs. 71.6%). Among remedial students in 2-year colleges, remediation time college enrollment, college sector, college major, and number of courses taken in the first term.

Table 1. Sample means for key analysis variables by postsecondary remediation status (n = 3,129).

| Remediation (1st year)                  | 2-Year College | 4-Year College |
|-----------------------------------------|----------------|----------------|
| Any remediation                         |                |                |
| Only math                               | 0.773          | 0.716          |
| Only English                            | 0.134          | 0.141          |
| Both math & English                     | 0.204          | 0.286          |
| College outcomes                        |                |                |
| Transferred up by 2nd year              | 0.066          | —              |
| Transferred up by 3rd year              | 0.125          | —              |
| Transferred down by 2nd year            | —              | 0.077          |
| Transferred down by 3rd year            | —              | 0.110          |
| Earned AA within 3 years                | 0.076          | 0.041          |
| Earned AA within 4 years                | 0.108          | 0.057          |
| Earned BA within 4 years                | 0.017          | 0.316          |
| Earned BA within 6 years                | 0.084          | 0.560          |
| Earned BA within 8 years                | 0.119          | 0.609          |
| Demographics                            |                |                |
| Female                                  | 0.493          | 0.473          |
| White                                   | 0.639          | 0.526          |
| Black                                   | 0.155          | 0.294          |
| Hispanic                                | 0.143          | 0.077          |
| Other race                              | 0.063          | 0.110          |
| Parents’ highest education              | 13.24          | 14.70          |
| Cognitive score (ASVAB)                 | (3.54)         | (3.44)         |
| High school math - High                 | 0.198          | 0.510          |
| Age when starting college               | 20.14          | 19.11          |
| On-time college attendance              | 0.473          | 0.778          |
| Number of courses (1st year)            | 7.02           | 10.21          |
| Number of students                      | 1,474          | 1,655          |

Source: National Longitudinal Survey of Youth 1997.

Note. n = sample size; AA = associate degree; BA = bachelor’s degree; AVSAB = Armed Services Vocational Aptitude Battery. Sample was restricted to first-time college students who had valid information on their college’s institutional level. Data are weighted to be generalizable to the population of youth aged 12–16 years old in 1996 in the United States. Standard deviations appear in the parentheses below the means of continuous variables.
enrollment in both subjects was the majority (56.3%), followed by enrollment in English only (26.4%) and math only (17.3%), whereas in 4-year colleges, remediation enrollment in both subjects (40.3%) and in English only (49.9%) was more common than it was in math only (19.8%).

Across baseline characteristics, there were clear similarities and differences by remediation status for 2-year and 4-year college students. Compared with their nonremediated peers, remedial students tended to be younger when first enrolling, be on-time college entrants, and take more courses during their 1st year across both types of postsecondary institutions. Black students were enrolled in any remedial courses at a higher rate in both 2-year and 4-year colleges, whereas Hispanic students were enrolled in any remedial courses at a higher rate in 4-year colleges but at a lower rate in 2-year colleges. Individuals who had lower ability and poorer academic preparation and those from families with lower parental education were more likely to be enrolled in remedial courses at 4-year universities but were less likely to take remedial courses at 2-year institutions. This set of descriptive statistics on the academic and family background of remedial students suggests that estimating the impact of remediation needs to address a potential positive selection bias issue in 2-year colleges and a potential negative selection bias issue in 4-year colleges.

**Analytic strategy**

Estimating the impact of postsecondary remediation with nonexperimental data such as NLSY97 was challenging because students who participate in remediation tend to be systematically different from their nonremedial peers. Two important selection mechanisms were likely to affect remediation enrollment. Students who have weaker academic skills tend to be placed in a remedial class upon entering college. Furthermore, students who aspire to succeed in college enroll in these remedial courses and work harder than their equal-ability peers who do not take these courses. Simply comparing the outcomes of remediated students to their nonremediated counterparts would yield estimates of remediation effects that would be biased downward in the first instance and biased upward in the second instance. To minimize the potential selection bias when estimating the postsecondary remediation effects with the observational data from NLSY97, this study employed the method of marginal means weighting through stratification (MMW-S), which can effectively remove selection bias associated with observed pre-treatment covariates under the strong ignorability assumption that the treatment assignment was independent of the unobserved characteristics given the measured covariates (Rosenbaum & Rubin, 1983, 1984).

The MMW-S method was recently developed for evaluating the effects of multivalued and multiple concurrent treatments with nonexperimental
data (Hong, 2010, 2012). It was particularly useful for this analysis because the remediation treatment was defined by a categorical variable with four groups: “only-math remediation,” “only-English remediation,” “both-subject remediation,” and “no remediation (as a reference group).” The MMW-S method combines the principle of inverse probability of treatment weights (Robins, 1999; Rosenbaum, 1987) with stratification on the propensity score (Rosenbaum & Rubin, 1984). It functions in the spirit of approximating a randomized controlled experiment by facilitating direct comparisons between individuals in a “treatment group” and those in a “comparison group,” both of whom have very similar chances of being assigned to the treatment.

To implement the MMW-S method for estimating the postsecondary remediation effects, this study followed the procedures laid out by Hong (2010, 2012). First, there were a number of observed pretreatment covariates that were identified as being correlated with remediation treatment status (for 2-year college analysis, 31 covariates; for 4-year college analysis, 37 covariates). For covariates with missing values (see Online Appendix Table A1), indicators of missing data were created to account for different missing patterns. Then, a multinomial logistic regression model at the individual level was estimated for obtaining three propensity scores per individual for three of the four remediation treatment statuses. Those individuals who had a nonzero probability of being assigned in each of the four remediation treatment statuses were included in the analytic sample for causal inference, which consisted of 1,389 students for 2-year college analysis (after dropping 5.8% of students) and 1,538 students for 4-year analysis (after dropping 7.1% of students).

With the estimated propensity scores, the analytic sample was stratified into either five or six strata for each of the four remediation treatment conditions. According to Cochran (1968), dividing a sample into five strata typically removes at least 90% of the bias associated with a pretreatment covariate and reduces the potential selection bias to a great extent. The next step was to compute a marginal mean weight for each individual in each treated group. The weight to be applied to units assigned to each treated group was similar to poststratification by weighting in survey sampling when a sample is not representative of the population due to disproportionate sampling or nonresponse (Horvitz & Thompson, 1952; Little, 1982). After repeating the same procedure for all four treatment groups, the weighted sample in theory approximated a randomized experiment within each stratum of students under the assumption of no unmeasured confounders. The covariate balance between the treated students and untreated students in the distribution of all pretreatment covariates was empirically examined further using weighted analysis of variance (ANOVA). One hundred percent and 97.5% of the 40 pretreatment covariates used in the 2-year and 4-year college
analyses, respectively, showed insignificant differences across the weighted remediation treatment groups, suggesting that the four weighted treatment groups became comparable (see Online Appendix Table A2 for the results of covariate balance tests).

Finally, to estimate the postsecondary remediation effects on college attainments, a weighted regression model was specified:

\[ Y_i = \beta_0 + \beta_1 Math_i + \beta_2 English_i + \beta_3 Both\_Subject_i + \epsilon \]  

where \( Y_i \) denotes the attainment outcomes (i.e., college persistence, transfer, and completion) for student \( i \). \( Math_i \), \( English_i \), and \( Both\_Subject_i \) are dummy variables for whether student \( i \) enrolled in (a) only-math remediation, (b) only-English remediation, and (c) both-subject remediation (the omitted group was “no remediation”), respectively. \( \epsilon \) represents an error term. Because the dependent variables were dichotomous, Equation (1) was estimated with a linear probability model (LPM)\(^8\) with marginal means weight computed. When examining the heterogeneous effects of postsecondary remediation by student subgroups, the above MMW-S procedures were replicated using subsamples restricted to a given racial/ethnic or SES subgroup (i.e., minority students in 2-year institutions, students with low parental education in 4-year institutions).\(^9\)

**Results**

The estimated impact of postsecondary remediation enrollment on attainment outcomes

The empirical findings in this study indicated that postsecondary remediation enrollment had differential effects on 2-year and 4-year college students and the impacts varied across remediation enrollment patterns. Table 2 displays results from LPMs estimating the remediation effects on attainment outcomes, including college transfer and completion, that are measured at various time points. The left panel of Table 2 presents the impact estimates of three remedial treatment groups (i.e., only-math, only-English, and both-subject remediation; the reference group was “no remediation”) for 2-year college students, whereas the right panel of Table 2 presents estimates for 4-year college students.

For 2-year college students, enrolling in any remediation generally had no impact on a variety of student outcomes as measured by college transfer and degree receipt. The estimates were either essentially 0 or were smaller than their standard errors, with few notable exceptions. It appeared that remediation enrollment in both math and English increased the probability of transferring up to a 4-year college by the end of a student’s 3rd year of college by about 6.4 percentage points and eventually improved the
likelihood of obtaining a BA degree within 8 years by about 6.5 percentage points. Both positive estimates were significant at the critical level of 5%.

When 4-year college student samples were analyzed, there was a clear pattern that remediation in any subject area—only math, only English, or both subjects—significantly increased the likelihood of transferring down to a 2-year college by the end of a student’s 2nd year by about 6.8 percentage points to 9.4 percentage points and by the end of the student’s 3rd year by about 10.4 percentage points to 11.6 percentage points. Moreover, participating in only-English remediation appeared to have no impact on graduation timing, but participating in at least a math remedial course significantly increased the time to earn a BA. In particular, enrolling in only-math remediation and both-subject remediation decreased the likelihood for an undergraduate to graduate on time (within 4 years) by 12.7 percentage points and 13.3 percentage points, respectively. When considering a longer duration before graduation, the estimated probabilities of earning a 4-year college degree within 6 years and 8 years for only-math and dual-subject remedial students were much smaller and not significant.

### Table 2. Effects of 1st-year postsecondary remediation enrollment for 2-year and 4-year college students.

| Dependent Variable | 2-Year College | 4-Year College |
|--------------------|----------------|----------------|
|                    | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects |
| Transferring       |           |             |               |           |             |               |
| Transferred up in 2nd year | .002     | -.001       | .022          | —         | —           | —             |
|                    | (.031)   | (.028)      | (.029)        | —         | —           | —             |
| Transferred up in 3rd year | .055     | .025        | .064*         | —         | —           | —             |
|                    | (.037)   | (.031)      | (.031)        | —         | —           | —             |
| Transferred down in 2nd year | —        | —           | —             | .072***   | .094***      | .068***       |
|                    | —        | —           | —             | (.018)    | (.017)      | (.016)        |
| Transferred down in 3rd year | —        | —           | —             | .104***   | .116***      | .116***       |
|                    | —        | —           | —             | (.024)    | (.019)      | (.021)        |
| College Attainment |           |             |               |           |             |               |
| Earned AA within 3 years | .030     | .043†       | .016          | —         | —           | —             |
|                    | (.027)   | (.024)      | (.019)        | —         | —           | —             |
| Earned AA within 4 years | .032     | .050        | .029          | —         | —           | —             |
|                    | (.037)   | (.035)      | (.030)        | —         | —           | —             |
| Earned BA within 4 years | —        | —           | —             | -.127***  | -.058       | -.133***      |
|                    | —        | —           | —             | (.048)    | (.043)      | (.046)        |
| Earned BA within 6 years | -.002    | .006        | .023          | -.061     | -.015       | -.094†        |
|                    | (.032)   | (.032)      | (.029)        | (.060)    | (.054)      | (.056)        |
| Earned BA within 8 years | .033     | .025        | .065*         | -.076     | .003        | -.062         |
|                    | (.035)   | (.032)      | (.031)        | (.061)    | (.054)      | (.056)        |
| Number of observations | 1,389    | —           | —             | 1,538     | —           | —             |

Note. AA = associate degree; BA = bachelor’s degree. Each cell in the table shows the estimate on a dummy variable indicating the effect of a specific type of remediation enrollment by subject using “no remediation” as the reference group. Robust standard errors are reported in parentheses.

*** p < .001. ** p < .01. * p < .05. † p < .10 (two-tailed test).
**Sensitivity analyses**

The main analytic sample in this study involved both traditional and non-traditional college students and oversampled minority students in NLSY97. As a first set of sensitivity analyses, a series of additional MMW-S models were estimated to assess the sensitivity of the estimates to the sample selection by using subsamples that were (a) limited to traditional students who were aged 18 years to 20 years, first-time students, on time (enrolled within a year from high school graduation), and full-time college students; and (b) restricted to NLSY97 cross-sectional participants, excluding the oversampled minorities. Online Appendix Table A3 and Table A4 show estimates from sensitivity tests for both 2-year and 4-year college student samples. Although the results did not qualitatively alter the main conclusions, two particular findings deserve mention. It appears that the positive effect of dual-subject remediation enrollment on transferring up to a 4-year college and earning a BA was substantially larger for traditional students in 2-year colleges. Furthermore, enrolling in any remedial courses significantly improved the probability of obtaining an AA for traditional students in 2-year colleges.

A propensity score-based analysis such as the MMW-S method employed in this study can produce unbiased estimates of treatment effects under the assumption of strongly ignorable treatment assignment, which requires all relevant covariates to have been measured (Rosenbaum & Rubin, 1983, 1984; Rubin, 2005). Although this analysis included a rich set of individual and contextual measures that were correlated with remediation treatment conditions, there may have been important unobserved confounding factors. To address this potential confounding issue, as a second set of sensitivity analyses, this study followed the sensitivity analysis procedures suggested by Frank, Maroulis, Duong, and Kelcey (2013) to quantify how much bias there must be in the estimates to invalidate the inferences. As defined by Frank et al. (2013), the calculation of proportion of bias to make an inference invalid is the following:

\[
\frac{\text{Bias Necessary to Invalidate an Inference}}{\text{Threshold for Inference} \times \text{Estimated Effect}} = 1 - \frac{t_{\text{critical, df}}}{\text{s.e.}}
\]

where the threshold for inference = s.e. × \( t_{\text{critical, df}} \). Applied to the estimates of this study, to invalidate the inference of the effect of both-subject remediation on transferring up to a 4-year college by the end of a student’s 3rd year and attaining a BA degree within 8 years for 2-year college students, biases must have accounted for \((1 - 1.96 \times .031 / .064 = .054)\), about 5.4% and 6.2% of the estimated effect to invalidate the inference. Similar calculations suggested that about 23.3% to 33.1% bias must be present to invalidate the inference of the estimated effect of any remediation on transferring downward for 4-year college students. Further, for the analysis of 4-year college students, the bias necessary
to invalidate the inferences of the estimated effect of only-math and both-subject remediation on obtaining a BA within 4 years was 13.5% and 15.8%, respectively. According to Frank et al. (2013), the median level of robustness is about 25% for observational studies in education. Thus, in this analysis, the estimated impacts of any remediation on college transfer for 4-year college students were quite robust, although they were less so for other sets of findings.

**Heterogeneous effects of postsecondary remediation enrollment across student subgroups**

Having used the full sample to identify whether and the extent to which an association among various remediation conditions and college attainments exists, the second part of this analysis focused on exploring the heterogeneous effects of postsecondary remediation across social subgroups. For racial subgroup analysis, White and Non-White students were the two contrasting groups within 2-year and 4-year colleges, respectively. For SES subgroup analysis, this study divided students based on their parental education and by college types. For 2-year colleges, the comparison groups were students whose parents had no college education versus students whose parents had at least some college education, whereas for 4-year colleges, the comparison groups were students whose parents had some college education or less versus students whose parents had a BA or more. In doing so, the SES subgroup comparison was between students who were pursuing more education than their parents, who likely lacked the necessary college knowledge and experience, and their counterparts whose parents had at least the same level of higher education.

The left and middle panels of Tables 3 and 4 display the estimated coefficients of heterogeneous impacts of remediation for 2-year and 4-year college students, respectively. Robust standard errors for each coefficient are reported in each corresponding cell in Online Appendix Table A5 and Table A6. Following Cohen (1983), Z tests of the differences between coefficients were conducted. The computed differences in remediation effects between subgroups are reported in the right panel of Tables 3 and 4. Corresponding Z scores are displayed in the right panel of Tables A5 and A6 in Online Appendix.

Generally, there was no clear pattern that any remediation enrollment would benefit or harm a certain subgroup of students based on race/ethnicity or SES at both 2-year and 4-year institutions; however, two sets of results are worth noting. There was some suggestive evidence that at 2-year colleges, students with low parental education who enrolled in only-math or both-subject remediation were more likely to earn an AA compared with their counterparts whose parents had some college education. However, positive differential effects of remediation for low-SES students were not found when examining the college outcomes of earning a BA degree in the long run.
Table 3. Heterogeneous effects of postsecondary remediation enrollment for 2-year college students.

|                        | (1) Only Math | (2) Only English | (3) Both Subjects | (4) Only Math | (5) Only English | (6) Both Subjects | (1)–(4) | (2)–(5) | (3)–(6) |
|------------------------|---------------|------------------|-------------------|---------------|------------------|-------------------|---------|---------|---------|
|                        | Non-White     | White            |                    | Non-White     | White            |                    | Difference between subgroups |
| Transferred up by 2nd year | 0.017 | 0.011 | 0.032 | -0.016 | -0.000 | 0.042 | 0.033 | 0.011 | -0.010 |
| Transferred up by 3rd year | 0.056 | 0.032 | 0.054** | 0.083 | 0.070 | 0.113** | -0.027 | -0.038 | -0.059 |
| Earned AA within 3 years | 0.057* | 0.028* | 0.045** | -0.008 | 0.075 | -0.007 | 0.065 | -0.047 | 0.052 |
| Earned AA within 4 years | 0.074 | 0.038 | 0.041 | 0.011 | 0.087† | 0.037 | 0.063 | -0.049 | 0.004 |
| Earned BA within 6 years | 0.020 | 0.046* | 0.056*** | -0.002 | 0.039 | 0.041 | 0.022 | 0.007 | 0.015 |
| Earned BA within 8 years | 0.063* | 0.051* | 0.090*** | 0.027 | 0.070 | 0.091* | 0.036 | -0.019 | -0.001 |
| Number of observations  | 689 | 661 | | |

|                        | Parents' highest education: HS or less | Parents' highest education: More than HS | Difference between subgroups |
|------------------------|----------------------------------------|----------------------------------------|-------------------------------|
| Transferred up by 2nd year | -0.019 | -0.009 | 0.015 | -0.037 | 0.003 | 0.045 | 0.018 | -0.012 | -0.030 |
| Transferred up by 3rd year | 0.073 | -0.002 | 0.034 | -0.044 | 0.029 | 0.090* | 0.117 | -0.031 | -0.056 |
| Earned AA within 3 years | 0.066† | 0.040† | 0.058** | -0.037 | 0.046 | -0.018 | 0.103† | -0.006 | 0.076 |
| Earned AA within 4 years | 0.091* | 0.059* | 0.089** | -0.041 | 0.050 | -0.001 | 0.132* | 0.009 | 0.090† |
| Earned BA within 6 years | 0.015 | 0.018 | 0.039† | -0.049 | -0.008 | 0.036 | 0.064 | 0.026 | 0.003 |
| Earned BA within 8 years | 0.038 | 0.025 | 0.065* | -0.023 | 0.006 | 0.066 | 0.061 | 0.019 | -0.001 |
| Number of observations  | 554 | 693 | | |

Note. HS = high school; AA = associate degree; BA = bachelor’s degree. “No remediation” is the reference group. Robust standard errors for each coefficient (in Columns [1]–[6]) and z scores for each test of significant difference (in Columns [7]–[9]) are reported in Online Appendix Table A5.

*** p < .001. ** p < .01. * p < .05. † p < .10 (two-tailed test).
Table 4. Heterogeneous effects of postsecondary remediation enrollment for 4-year college students.

|                        | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects |
|------------------------|-----------|--------------|---------------|-----------|--------------|---------------|-----------|--------------|---------------|-----------|--------------|---------------|
|                        | Non-White | White        |               | Non-White | White        |               | Non-White | White        |               | Non-White | White        |               |
| Transferred down by 2nd year | .047†    | .100***      | .070***       | .075**    | .084***      | .059**        | −.028     | .016         | .011          | .017      | .024         | .006          |
| Transferred down by 3rd year | .101*    | .129***      | .118***       | .084**    | .105***      | .112**        | .093      | −.012        | .126          | .017      | .024         | .006          |
| Earned BA within 4 years | −.068    | −.054        | −.067         | −.161**   | −.042        | −.193***      | −.009     | −.161        | −.205         | .042      | −.215†       | −.067         |
| Earned BA within 6 years | −.053    | −.065        | −.081         | −.044     | .096*        | −.058         | .017      | .024         | .026          | .026      | .028         | .026          |
| Earned BA within 8 years | −.007    | −.105        | −.092         | −.049     | .110*        | −.025         | .042      | −.215†       | −.067         | .017      | .036         | .026          |
| Number of observations  | 566       | 899          |              | 835       | 572          |               |           |              |               |           |              |               |

|                        | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects | Only Math | Only English | Both Subjects |
|------------------------|-----------|--------------|---------------|-----------|--------------|---------------|-----------|--------------|---------------|-----------|--------------|---------------|
| Parents’ highest education: Less than a BA | .067*** | .082*** | .061*** | .055* | .090*** | .123** | .012 | −.008 | −.062 | .026 | .018 | −.202 |
| Parents’ highest education: BA or more | .106** | .115*** | .130*** | .080† | .097** | .150** | .091 | .188† | .246* | .013 | .028 | .026 |
| Earned BA within 4 years | −.155** | −.062 | −.115* | −.246* | −.250** | −.361*** | .091 | .188† | .246* | .013 | .028 | .026 |
| Earned BA within 6 years | −.112 | −.093 | −.144* | −.099 | −.121* | −.170* | −.013 | .028 | .026 | .017 | .036 | .026 |
| Earned BA within 8 years | −.135† | −.083 | −.126† | −.118 | −.119* | −.152* | .017 | .036 | .026 |           |              |               |
| Number of observations  | 835       | 572          |              |           |              |               |           |              |               |           |              |               |

Note. BA = bachelor’s degree. “No remediation” is the reference group. Robust standard errors for each coefficient (in Columns [1]–[6]) and z scores for each test of significant difference (in Columns [7]–[9]) are reported in Online Appendix Table A6.

*** p < .001. ** p < .01. * p < .05. † p < .10 (two-tailed test).
Furthermore, at 4-year colleges, the negative impact of dual-subject remediation on on-time graduation was larger for high-SES students than for their low-SES peers.

Discussion

The goal of this study was to investigate whether and for whom postsecondary remediation has an impact on college outcomes. The analysis of the NLSY97 data arrived at conclusions that both validated and extended previous work on postsecondary remediation. As with most previous studies, this study showed insignificant effects of remediation on a series of student outcomes, particularly for 2-year college students. However, three clear sets of findings emerged from this analysis. Two-year college students who enrolled in both math and English remedial subjects had a higher likelihood of transferring upward to a 4-year college and earning a BA in the long run. For 4-year college students, however, enrolling in any postsecondary remediation—only math, only English, or both subjects—during their 1st year in college increased the likelihood of transferring downward to a 2-year college in the following years. It also appeared that enrolling in at least a math remedial class (i.e., only math and both subjects) hindered 4-year college students from graduating on time.

Why does enrolling in remedial courses during the 1st year of college positively affect 2-year college students, especially those who enrolled in both math and English remedial subjects, on college transfer and completion but generally negatively affect college attainment for 4-year college students? One possible explanation is that taking and completing remedial classes might help improve the academic preparation and credentials for 2-year college students to apply and transfer to a 4-year college. However, such a benefit of remediation is not experienced by remedial students in 4-year colleges. Another possible explanation is that the negative function of remediation triggered by stigma might outweigh its positive developmental function at 4-year colleges but not 2-year colleges. At 4-year colleges, those students who enrolled in remedial courses may feel more of a stigma as they are an outnumbered group.

When compared with another previous national study by Attewell et al. (2006), findings from this study analyzing a more recent nationally representative sample offered newer insights into the remediation effects of different subjects. Attewell et al. reported that math remediation negatively correlated with graduation for 2-year college students, but the negative effect was weak or nonexistent for 4-year college students. Their study also revealed a positive impact of reading remediation on graduation for 2-year college students but a negative impact for 4-year college students. The mixed effects of math and reading remediation for 2-year and 4-year college students documented by Attewell et al. are difficult to interpret as they were likely
confounded by the potential interaction effects of another remedial subject that were not accounted for in the analysis. Instead, the findings of this national study presented a set of empirical evidence showing a consistent pattern of the effects of remediation in math only, English only, or both subjects. This study also extended the remediation literature in one important way by demonstrating that the effect of dual-subject remediation, which is a common remedial scenario among college freshmen, is not simply the sum of effects of individual remedial subjects.

In terms of subgroup analysis, the findings on the heterogeneous effects of remediation in this study contribute to the understanding of the role of postsecondary remediation in educational inequality. One major finding was that at 2-year colleges, enrolling in at least a math remedial class—only math or both subjects—might help low-SES students in obtaining an AA. However, the positive effects of remediation on AA degree completions did not translate into reducing the racial gap in 4-year college degree attainment in the long run. The NLSY97 data further showed that at 4-year colleges, enrolling in any remedial course had a larger negative impact on on-time graduation for high-SES students than for low-SES students but the differential effects faded away over a longer period.

The findings presented in this study have important substantive and methodological implications for research on postsecondary remediation, yet they must be interpreted with several limitations in mind. First, this study did not directly test the hypotheses concerning the remediation functions including cognitive development or stigma effect. Similar to most previous studies, the estimated effects of remediation in this study could be interpreted as joint effects of all possible combinations of remediation functions. Another limitation is that although this study demonstrated the importance of characterizing remediation patterns based on the subject areas and the number of remedial courses taken during a student’s 1st year in college, the four remedial treatment groups in this study (i.e., only math, only English, both subjects, and no remediation) may not represent all possible remediation scenarios in higher education and do not take into account levels of remediation. Many students, especially those who are disadvantaged students attending a community college, would need to take more than 1 year and multiple levels of remedial courses to complete the sequence of required remediation (Attewell et al., 2006; Bahr, 2010; Bailey et al., 2010; Boatman & Long, 2010; Parsad et al., 2003). Future research should extend the approach proposed in this study to examine the outcomes of students who enrolled in multiple levels and years of remediation.

Despite these limitations, this analysis drew attention to the general and differential effects of postsecondary remediation on college attainment across college types and student subgroups. Drawing on recent national data from NLSY97, this study provided updated national estimates on postsecondary remediation patterns and showed that a considerable number of remedial
students in both 2-year and 4-year colleges enrolled in single as well as multiple remedial subjects during their 1st year in college. This study is also the first large-scale national analysis to offer impact estimates of single-subject and dual-subject remediation on postsecondary outcomes as measured by college transfer and completion at multiple time points. Finally, by presenting the heterogeneous effects of remediation for various social subgroups, this analysis highlighted that postsecondary remediation may help and hinder students differently based on their racial/ethnic group and SES.

Notes

1. The present study focused on examining remediation enrollment, not remediation referral or completion, for which readers can refer to the studies by Bailey et al. (2010) and Scott-Clayton and Rodriguez (2015).
2. As documented in Sparks and Malkus (2013), 24.7% of 1st-year undergraduates whose parents had a high school diploma or less reported taking remedial courses, compared with 20.4% of those whose parents had a bachelor’s degree or higher. While only 19.9% of White students reported taking remedial courses, 30.2% of Black students and 29.0% of Hispanic students did.
3. Two other experimental studies focused on examining the effect of summer bridge remedial programs (Barnett et al., 2012) and learning community components in a remedial program (Visher, Weiss, Weissman, Rudd, & Wathington, 2012).
4. The CCM code for remedial math is “32.0104,” and the code for remedial English is “32.0108.”
5. The outcome measure of earning a BA degree within 4 years was not used as a dependent variable for 2-year college students because it was very infrequent in the data (see Table 1). Similarly, the outcome measures of obtaining an AA degree within 3 years and 4 years were not used as dependent variables for 4-year college students.
6. All covariates listed in Online Appendix Table A1 were used to predict remedial treatment status in a series of bivariate multinomial logistic regression models. For 2-year college students, 31 covariates were significantly correlated with remedial treatment conditions (at the critical level of 10%), except race/ethnicity, late for school, absent from school, percentage of peers who cut classes, high school sector, and high school science pipeline; for 4-year college analysis, 37 covariates were significantly correlated, except gender and high school program.
7. In comparison with the students included in the analytic sample, those excluded from the analytic sample tended to be individuals who were less likely to share similar characteristics with their peers across treatment conditions. For example, the “no-remediation” students excluded from the 4-year college sample on average had cognitive scores that were about 0.5 standard deviations above the mean. They were likely to be high-ability students for whom it is difficult to find “matched” cases in any remediation treatment groups.
8. Additional analyses showed that the average marginal effects computed from logistics regression models were essentially very similar to those estimates from LPMs (results available upon request).
9. Across the eight subgroup analyses, the proportion of covariates remaining significantly different among the remediation treatment groups ranged from 0% to approximately 5% after the steps of propensity score stratification and weighting. In theory, 5%
of the covariates could show statistical imbalance among the treatment groups at the significant level of .05 even in a properly implemented experimental study.

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