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ISSUES & ANSWERS REL 2008–No. 058

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July 2008

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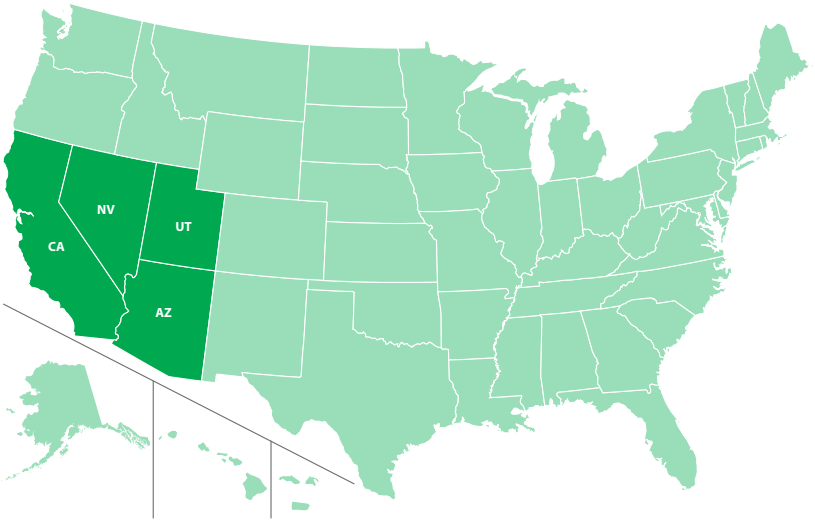

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This report is available on the regional educational laboratory web site at http://ies.ed.gov/ncee/edlabs.

Summary

REL 2008–No. 058

Examining the links between grade 12 mathematics coursework and mathematics remediation in Nevada public colleges and universities

This study examines the links between Nevada's grade 12 mathematics courses and remedial mathematics courses in Nevada's public colleges and universities. It analyzes remediation rates by students' highest grade 12 mathematics course level and mathematics grade point average and by various student and school characteristics.

This study of the links between Nevada's grade 12 mathematics courses and college mathematics remediation in Nevada's public colleges and universities was guided by four questions:

- Which mathematics courses did Nevada students complete in grade 12, and how well did they do?
- What were the remediation rates for each level of mathematics courses that students completed in grade 12, and how did the rates differ by student performance in those courses?
- How did the remediation rates differ by other student characteristics—race/ethnicity, gender, and type of public college attended (two-year, four-year, or combination)?
- How did the remediation rates differ by type of high school attended in grade 12, as measured by locale and by whether the school made adequate yearly progress that year under the No Child Left Behind Act of 2001?

The study calculated the college mathematics remediation rate of recent high school graduates in Nevada and disaggregated it by the highest level of mathematics courses completed during the students' senior year in high school and by the combination of the highest level of mathematics courses taken and the students' grade 12 mathematics grade point average (GPA), among other factors.

The analysis is based on the population of 4,653 students who graduated from a Nevada public high school in 2006 and enrolled in at least one mathematics course in a Nevada public college or university in the 2006/07 school year. Following the scheme developed by Burkam and Lee (2003), these students were sorted into eight categories based on the highest level of mathematics courses completed in grade 12, from No mathematics (students who did not enroll in any mathematics courses and students who enrolled but did not receive a passing grade in any mathematics courses) and Nonacademic (such

as consumer mathematics) and Low academic, through Middle I and II, to Advanced I–III.

The results show that whether students enroll in remedial mathematics as freshmen in college is related to the mathematics courses students completed in grade 12 and their performance in these courses. More specifically, the results show that:

- More than a third (37.6 percent) of students enrolled in remedial mathematics during their first year in higher education.

- Students who completed more advanced courses in grade 12 had lower rates of remediation, on average, than those who completed lower level courses. For the 495 students who had completed a Middle II course, 63.2 percent enrolled in a remedial mathematics course during their first year of college. For the 923 students who had taken the next higher level of mathematics (Advanced I), the rate was less than half that, at 31.5 percent. The remediation rate was halved again for the 708 students who had taken the next higher level of mathematics (Advanced II), at 15.4 percent, and it dropped to 2.7 percent for the 521 students who had completed the most advanced mathematics level (Advanced III). Completing higher level courses does not necessarily cause the lower remediation rates, however, and due to possible selection bias issues this analysis is unable to ascertain whether getting students to enroll in higher level courses would lower their mathematics remediation rates in college.

- Students' enrollment in remedial coursework was related not only to the level of mathematics courses they completed in grade 12, but also to how well they did in those courses. Among students who completed a given mathematics level in grade 12, those with higher grade 12 mathematics GPAs tended to have lower rates of remediation. In addition, students who did well in a particular course often had lower remediation rates than students who took the next level of mathematics but did poorly in the class. For instance, students who completed an Advanced I course and had an average GPA of 4.0 (A) in their grade 12 mathematics studies had a lower remediation rate than students who completed an Advanced II course but had a GPA of 2.0 (C).

- A logistic regression analysis revealed similar relations between remedial mathematics and the highest level of mathematics completed in grade 12. After gender, race/ethnicity, and grade 12 mathematics GPA are controlled for, the probability of enrolling in mathematics remediation is almost two and a half times greater for students completing Middle II mathematics courses than for students completing the next higher level (Advanced I). Predicted probabilities were also estimated from the logistic regression model and show, for example, a predicted probability of enrolling in mathematics remediation of 45 percent for White male students who completed a Middle I course in grade 12 with an average mathematics GPA of 2.7. The predicted probability is only 8 percent for the same group of students who completed Advanced II courses.

This analysis may be useful to several groups in Nevada. For the Nevada System of Higher

Education, which requested the analysis, this report quantifies the proportion of Nevada students who enroll in the state's public colleges and universities directly from high school and who enroll in mathematics remediation. It also provides information about the academic background of those students. This report may also help parents, students, and educators better understand the likelihood that students completing particular mathematics courses in grade 12 will enroll in mathematics remediation before taking college-level mathematics courses. Finally, this study can serve as a starting point for discussions between K–12 and college administrators about what would be sufficient high school mathematics preparation for college-bound students.

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WHY THIS STUDY?

This report responds to concerns within the Nevada System of Higher Education about the number of Nevada high school graduates who seek a college education but may be unprepared for the rigors of beginning college-level courses. The state's public colleges and universities, which make up the Nevada System of Higher Education,[1] found that more than a third (36 percent) of the students who received a Nevada high school diploma in 2006 and enrolled in a Nevada public college or university the subsequent school year took at least one freshman remedial course in English or mathematics (Nevada System of Higher Education 2007). Among college freshmen taking remedial courses that year almost a third (31 percent) were enrolled in both remedial mathematics and remedial English. (For information about placement into remedial mathematics courses see box 1.)

The Nevada System of Higher Education (2007) estimates per credit expenditures for providing remedial instruction of $234 at community colleges and $293 at state college or universities, based on the state-supported operating budget and projected full-time faculty equivalents for each institution.[2] Breneman and Harlow (1998) estimate that during the mid-1990s remedial education absorbed about $1 billion of the annual $115 billion budget for public higher education nationwide. Merisotis and Phipps (2000) estimate an even higher cost of $2 billion, adjusting for what they identify as an underreporting of remedial expenditures calculated by Breneman and Harlow.

Remedial coursework is expensive for students as well in terms of their opportunity costs (Breneman and Harlow 1998). Since remedial courses typically do not count toward graduation requirements, students may need to remain in school longer before embarking on their income-earning years.

The aim of the study was to develop a more detailed picture of remediation rates in Nevada by examining student subpopulations and exploring the relationship between students' grade 12 coursework and

BOX 1

Placement into remedial mathematics at Nevada public colleges and universities

Remedial mathematics courses, such as Math 093 (pre-algebra), Math 095 (elementary algebra), and Math 096 (intermediate algebra), are equivalent across all Nevada System of Higher Education institutions. Across Nevada's public colleges and universities students are placed in freshman remedial courses based on their scores on the ACT or Scholastic Assessment Test or if they have not taken these standardized tests, on their scores on placement tests such as Compass and Accuplacer. The placement policies for these remedial courses tend to be similar, although not precisely the same, across these institutions, and practices are meant to follow a systemwide policy on mathematics placement (Nevada System of Higher Education 2007). (Table A7 in appendix A lists the placement practices at each institution).

Accordingly, students might not enroll in remedial classes despite scores below the cutoff on placement tests or might enroll despite scores above the cutoff. Reasons vary. A student may obtain permission to enroll in college-level coursework despite a low test score, or a student with a higher score may feel the need for a refresher course, for example.

their enrollment in remedial courses in college. While the need for remediation is a concern for both English and mathematics courses, this study focuses on mathematics because mathematics courses are more naturally sequential and easier to categorize.

The study was guided by four questions:

- Which mathematics courses did Nevada students complete in grade 12, and how well did they do?
- What were the remediation rates for each level of mathematics courses that students completed in grade 12, and how did the rates differ by student performance in those courses?
- How did the remediation rates differ by other student characteristics—race/ethnicity, gender, and type of public college attended (two-year, four-year, or combination)?
- How did the remediation rates differ by type of high school attended in grade 12, as measured by locale and by whether the school made adequate yearly progress that year under the No Child Left Behind Act of 2001?

To answer these questions, the grade 12 and college freshman year transcripts of Nevada students were examined (see box 2 and appendix A for details). The initial dataset of 8,264 students included transcripts of students who graduated from a Nevada public high school in 2006 (obtained by special permission from the Nevada Department of Education) and enrolled in a Nevada System of Higher Education institution in fall 2006 or spring 2007 (obtained by special permission from the Nevada System of Higher Education). The 3,611 students who did not enroll in any mathematics course in college during the period under observation were excluded from the analysis because there was no way to determine whether they would eventually enroll in remedial mathematics in college.[3] The final study population of 4,653 students consisted of all students who graduated from a Nevada high school in 2006 and enrolled in at least one mathematics course in a Nevada public college or university in the 2006/07 school year.

In addition to explaining the relation between mathematics coursework in grade 12 and remedial courses in college, this report details the extent of the remediation issue in the Nevada System of Higher Education and breaks it down by various subpopulations of students, such as race/ethnicity and gender. The report also details how remediation rates differ for students attending two- and four-year institutions.

Although the analysis shows a correlation between mathematics courses taken in grade 12 and remedial courses in college, the results cannot be interpreted causally. The reader should not infer,

BOX 2

Study methods and analyses

Descriptive analyses were performed to determine the highest level of mathematics that students completed (rather than attempted) in grade 12 and their average grade point average (GPA) for all mathematics courses in grade 12 (some students took more than one type of course; 15 percent took courses of different levels of difficulty). Based on the criteria of Burkam and Lee (2003), students' mathematics coursework was classified into eight categories—from no mathematics (which includes students who did not enroll in any mathematics courses and students who enrolled but did not pass) to Advanced III (such as calculus)—a classification scheme meant to measure how advanced the courses were (for details, see appendix A and table A1).

While the database from which the high school data were drawn did not have data for grades other than grade 12 (the data were obtained by special permission from the Nevada Department of Education), student performance in grade 12 has been shown to be highly correlated with student performance in other high school grades (see Roderick and Camburn 1999; Riegle-Crumb 2006; Cavanagh, Schiller, and Riegle-Crumb 2006). Remediation rates were then calculated and compared with student characteristics (highest level of mathematics completed in grade 12, grade 12 mathematics GPA, gender, race/ethnicity, and whether the student enrolled in a two- or four-year institution) and school characteristics (locale and whether the school made adequate yearly progress in 2006). Data for school characteristics came from the U.S. Department of Education, National Center for Education Statistics (2007) and the Nevada Department of Education (2007).

In addition to the descriptive analysis, multivariate analysis was conducted to investigate the correlation between mathematics remediation status and various student characteristics, while controlling for other student characteristics. The results of this analysis confirm the findings of the descriptive statistics (see appendix B for details).

for example, that changing specific student characteristics, such as the highest level of mathematics completed in grade 12, would cause remediation rates to change. Because of the nonrandom sorting of students into grade 12 mathematics courses, it is unclear from this analysis whether getting students to enroll in higher level courses would lower the remediation rates of these students. Students who complete higher level mathematics courses are likely to have more-advanced mathematics skills than are other students, which could explain their lower remediation rates. Students who complete higher level mathematics courses might also be more motivated and devote more time to mathematics than students who complete lower level courses.[4] The descriptive analysis conducted for this report does not account for this selectivity bias.

WHAT WE ALREADY KNOW ABOUT REMEDIATION AND THE IMPORTANCE OF GOOD PREPARATION FOR COLLEGE COURSEWORK

Research has illuminated the importance of high school coursework for college preparedness. Using descriptive statistics and logistic regressions to examine the transcripts of students enrolled at Utah Valley State College, Hoyt and Sorensen (1999, 2001) conclude that a student's high school coursework is correlated with the need for remedial education in college. They find that students earning higher grades and taking higher levels of mathematics and English courses in high school were less likely to need remedial courses in college. However, Hoyt and Sorensen also find that more than half the students who successfully completed intermediate algebra and geometry still required remedial mathematics courses or needed to repeat intermediate algebra in college. A recent report by ACT (2007), which analyzed 2006 high school graduates who took the ACT test, used descriptive statistics to show that students taking higher level mathematics courses in high school were less likely to enroll in remedial mathematics courses in college. However, the report also found, even among students who had completed the core curriculum in high school (three years of mathematics), that 84 percent were unprepared to take a credit-earning first-year college algebra course. The ACT report argues that taking the right kind

of courses mattered just as much as taking the right number of courses.

The findings of this report are consistent with those of Hoyt and Sorensen (1999, 2001) and ACT (2007) that a student's high school coursework and performance are correlated with the need for remedial education in college. This report illuminates that relationship, with a focus on recent high school graduates in Nevada.

Performing logistic regressions on data from the High School and Beyond dataset, Adelman (1999) finds that the academic resources (a composite of high school curriculum, test scores, and class rank) that a student brought to postsecondary education and continuous enrollment (no break in enrollment longer than one semester) were the two most important factors correlated with college completion. Of all precollege classes taken, the highest level of mathematics courses completed in high school had the strongest relation with degree completion in higher education. Completing a high school course beyond the level of algebra II more than doubled the odds that a student entering college would earn a bachelor's degree. In a follow-up study Adelman (2006) performed logistic regressions on the NELS: 88/2000 dataset to assess whether results had changed. Successful progress toward a bachelor's degree was still correlated with completion of a high school mathematics course beyond algebra II.

This study adds to the literature on the alignment between high school graduation requirements and requisite college skills and knowledge

This current study also adds to the literature on the alignment between high school graduation requirements and requisite college skills and knowledge. A lack of alignment makes the high school to higher education transition difficult and diminishes educational opportunities for many students. Manifestations of such lack of alignment include high rates of enrollment in remedial courses and a reliance on possibly inflated high school grades as predictors of college success (Kirst and Venezia 2001, Kirst 1998).

Conley (2001) reviews a National Commission on the High School Senior Year report and finds that the K–12 and postsecondary systems do not collaborate enough to align academic content, admissions procedures, and expectations for students. Kirst and Venezia (2001) note that while there are few incentives for the two systems to collaborate, common understanding and agreement on certain issues are important for improving academic outcomes for all students. They recommend that college-level expectations be made more explicit to K–12 stakeholders so that students are better prepared for the rigors of college coursework. Venezia, Kirst, and Antonio (2003), using data from the six-year national Stanford Bridge Project, describe the misalignment between education systems. They find that high school assessments emphasized different knowledge and skills than college placement exams.

Because mathematics coursework is hierarchical, students who enter high school performing at a higher mathematics level have a better chance of doing well throughout high school (Stevenson, Schiller, and Schneider 1994). Students who begin high school taking algebra I or geometry have a better chance of reaching advanced mathematics courses such as trigonometry and calculus (Riegle-Crumb 2006; Cavanagh, Schiller, and Riegle-Crumb 2006). Riegle-Crumb (2006), conducting hierarchical linear modeling on data from the National Longitudinal Study of Adolescent Health and the Adolescent Health and Academic Achievement Transcript Study, finds that student performance in one mathematics course is correlated with subsequent mathematics placement because of the sequential nature of mathematics coursework. Beginning early in high school, failure in mathematics classes had a negative relationship with the level of mathematics reached by the end of grade 12, while receiving high grades had a positive relationship.

The research articles discussed above were unable to employ random assignment or other quasi-experimental methods such as interrupted-time series or regression-discontinuity designs in order to adequately address issues of selection

bias. Using various multivariate techniques, these researchers examined the relations among various student outcomes of interest (such as enrolling in college, attaining a bachelor's degree, and enrolling in a remedial course) and other variables of interest (such as grade 9 coursework, highest course level completed in high school, continuous enrollment in college, and performance in academic courses). An understanding of these relations is valuable in disentangling the complex transition patterns from secondary to postsecondary education and in arriving at a better understanding of the relations between the two systems. However, a causal interpretation of the relations among these variables is unwarranted because of the possibility of selection bias. The current study also examines these types of relations and is unable to account for selection bias because of the nonrandom sorting of students into mathematics courses.

WHAT THE STUDY FOUND ABOUT GRADE 12 COURSEWORK

Almost half (46.2 percent) the study population (the cohort of students who graduated from a Nevada public high school in 2006 and enrolled in at least one mathematics course in a Nevada public college or university during the 2006/07 school year)[5] completed a course in one of the three advanced mathematics categories (Advanced I, Advanced II, and Advanced III) in grade 12.[6] Approximately a third (33.0 percent) of the study population did not complete any mathematics course in grade 12.

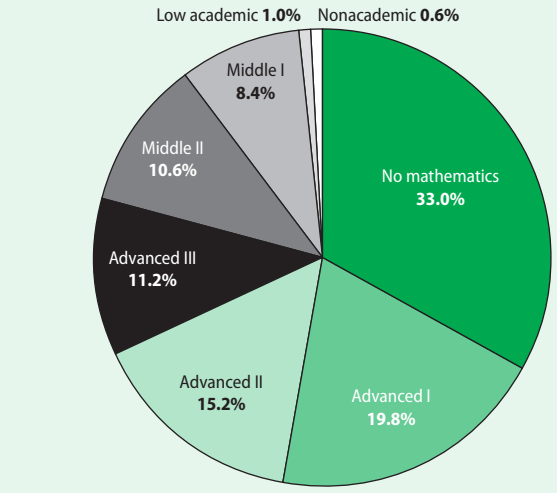
The overall remediation rate for the study population was 37.6 percent, but the range was wide across various subpopulations of students. Of students who completed Middle II courses, 63.2 percent enrolled in a remedial mathematics course during their first year of college. The rate was less than half that (31.5 percent) for the students who took the next more advanced level of mathematics (Advanced I) and half that again (15.4 percent) for the students who took the next higher level (Advanced II). The rate plummets to 2.7 percent for students who took the highest level courses (Advanced III). On average, students who completed higher level mathematics courses in grade 12 had lower rates of remediation than those who completed lower level courses. Also, students who performed better in their grade 12 mathematics courses tended to have lower rates of remediation than those who performed less well, as measured by their mathematics GPA.

The overall remediation rate for the study population was 37.6 percent, but the range was wide across various subpopulations of students

Which mathematics courses students completed in grade 12

Among the 46.2 percent of students in the study population who completed a course in one of the three advanced mathematics categories, the largest group, 19.8 percent of the total population, completed Advanced I mathematics (figure 1). This level includes such courses as algebra/trigonometry, trigonometry, and

FIGURE 1
Distribution of Nevada study population by highest level of mathematics course completed in grade 12, 2005/06 (percent)



Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education.

probability/statistics. About 15.2 percent of the study population completed an Advanced II course (such as pre-calculus), and 11.2 percent completed an Advanced III course (such as calculus).

Almost a third (33.0 percent) of the study population did not complete any mathematics courses in grade 12 (this category includes students who did not enroll in a mathematics course during their senior year and students who enrolled but did not pass the course with a grade of D or better).[7] Because of the nature of the data, it was not possible to determine the mathematics proficiency of students who did not complete a mathematics course in grade 12. It is possible that these students were highly proficient in mathematics and completed all the necessary mathematics coursework by grade 11. It is also possible that they were of low mathematics proficiency and chose not to take any mathematics courses in grade 12. With access to complete high school transcripts a future study might be able to determine whether the students who did not enroll in mathematics in grade 12 are of high or low ability based on courses taken in grades 9, 10, and 11.

Some 20.6 percent of students completed a Nonacademic, Low academic, Middle I, or Middle II course. The largest group, 10.6 percent, completed a Middle II course, followed by 8.4 percent, who completed a Middle I course. Finally, 1.0 percent completed a Low academic course and 0.6 percent a Nonacademic course. The fact that the study population consists only of students who enrolled in a mathematics course in a public Nevada college or university in the year after graduating from high school suggests that these are highly motivated students, which could explain why close to half of them (46.2 percent) completed an advanced level mathematics course.

Students completing Low academic courses had the highest average GPA (3.2), and students completing Advanced III courses had the second highest (3.1)

How students performed in their grade 12 mathematics courses

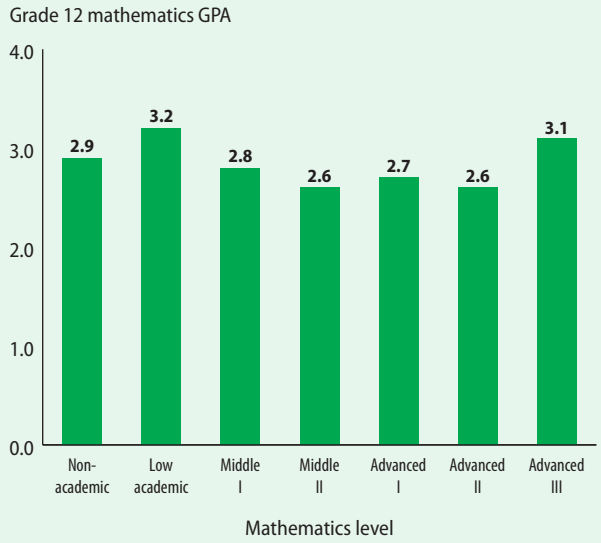
Grade 12 mathematics GPAs for each student were calculated by averaging grades earned in mathematics courses in grade 12 (with an A equal to 4.0 points, an A– to 3.7 points, a B+ to 3.3 points, a B to 3.0 points, and so on). Some students took only one semester of mathematics, while others took two or more during the year. Next, the average GPA among all students who completed a given mathematics level (such as Advanced I) was computed.[8] Disaggregated by the highest level of mathematics completed in grade 12, the average mathematics GPAs ranged from 2.6 to 3.2 (figure 2). Students completing Low academic courses had the highest average GPA (3.2), and students completing Advanced III courses had the second highest (3.1). Students completing courses in the Middle II and Advanced II categories had the lowest average GPA (2.6).

How remediation rates differ across subpopulations of students

While the overall remediation rate for the study population was 37.6 percent (table 1), the average

FIGURE 2

Average grade 12 mathematics grade point averages (GPAs) of Nevada study population by highest level of mathematics completed in grade 12, 2005/06



Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education.

TABLE 1

Freshman mathematics remediation rate in Nevada public colleges and universities for the Nevada study population, 2006/07

Mathematics remediation?	Number of students	Share of total (percent)
No	2,905	62.4
Yes	1,748	37.6
Total	4,653	100.0

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

remediation rate varied by the highest mathematics course taken and by mathematics courses and mathematics GPA, gender, race/ethnicity, and type of higher education institution attended. It also varied by two characteristics of the high schools that students attended: adequate yearly progress status and locale.

Remediation rate by course completion

Disaggregation of remediation rates by level of mathematics courses completed in grade 12 shows that students who completed higher level mathematics courses were less likely to enroll in remedial mathematics during their first year of college (table 2). As already discussed, students who completed higher level courses had lower rates of remediation than those who completed lower level courses, with the percentage taking remedial classes dropping from 63.2 percent for students who completed Middle II courses to 2.7 percent for students who completed an Advanced III course. While the remediation rates drop as students complete higher level courses, completing the highest level of mathematics still does not guarantee that a student will enroll in a college-level mathematics course: 14 of the 521 students who completed an Advanced III mathematics course in grade 12 enrolled in remedial mathematics during their first year of college.

TABLE 2

Freshman mathematics remediation rates in Nevada public colleges and universities for the Nevada study population by the highest level of mathematics completed in grade 12, 2006/07

Highest level of mathematics completed	Number of students	Percentage taking remedial courses
No mathematics	1,536	42.0
Nonacademic	30	83.3
Low academic	47	80.9
Middle I	393	79.6
Middle II	495	63.2
Advanced I	923	31.5
Advanced II	708	15.4
Advanced III	521	2.7

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

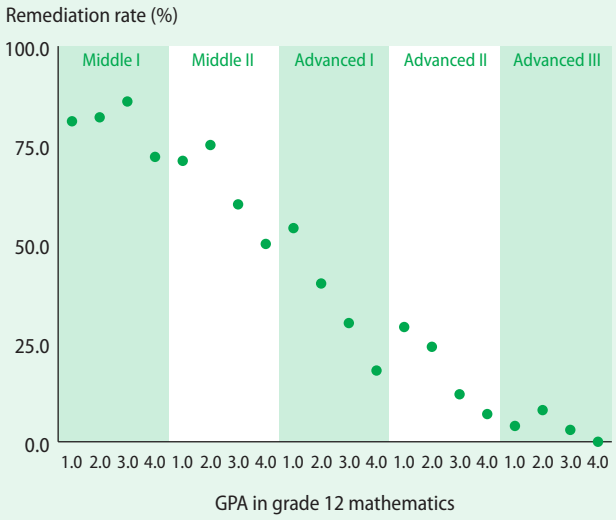
Remediation rate by courses completed and grade 12 mathematics grade point average

While remediation rates fall as the level of mathematics courses completed in grade 12 rises, what is the relation between student performance in those courses and remediation rates? For instance, is there a difference in remediation rates between students who completed an Advanced II course and had a grade 12 mathematics GPA of 2.0 and those who had a GPA of 3.0? Figure 3 disaggregates remediation rates by the highest mathematics course completed in grade 12 and the grade 12 mathematics GPA.[9] This figure enables a comparison of the remediation rates within mathematics levels for students who performed differently, as well as a comparison across mathematics levels for students with the same GPAs.

Remediation rates tend to decline with higher grade 12 mathematics GPAs within a given mathematics level. For example, for all courses students with a grade 12 mathematics GPA of 2.0 had a higher remediation rate than students with

FIGURE 3

Freshman mathematics remediation rate in Nevada public colleges and universities for the Nevada study population in 2006/07 by grade 12 mathematics grade point average (GPA) and highest level of mathematics completed in grade 12 in 2005/06 (percent)



Note: GPAs were rounded to the nearest whole number. Because of small sample sizes, the nonacademic and low academic categories were not plotted in this figure.

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

a GPA of 4.0 within the same level. This shows the relation between performance in mathematics and remediation.

Figure 3 also enables comparison of remediation rates across mathematics levels for students in a given level who perform well and students in the next higher level who do not perform as well. For example, the remediation rate for students who completed an Advanced I course and who had a grade 12 mathematics GPA of 4.0 was about 18 percent, which is lower than the 24 percent for students who completed the next higher level course (Advanced II) but had a GPA of 2.0. Students who completed an Advanced II course and had a mathematics GPA of 4.0 had a similar rate of remediation as those who completed an Advanced III course and had a GPA of 2.0. More generally, with the exception of students who completed a Middle II course, students who had a grade 12 mathematics GPA of 4.0 had a remediation rate at least as low as students who completed the next higher level course with a GPA of 2.0.

More than two-thirds of students who attended only a two-year college during 2006/07 enrolled in remedial mathematics, while 16.2 percent of those who attended only a four-year college did so

In addition, figure 3 permits comparisons of remediation rates across mathematics levels of students who perform poorly at a given level of mathematics and students who do better in the next lower level. For all courses students who had a grade 12 mathematics GPA of 1.0 at a given level had at least as low a remediation rate as students with a GPA of 3.0 in the next lower level. For example, students who completed Advanced I and had a GPA of 1.0 had a remediation rate of 54 percent, which is lower than the remediation rate of students who completed Middle II and had a GPA of 3.0.

Remediation rate by type of college attended

More than two-thirds of students (70.1 percent) who attended only a two-year college during 2006/07 enrolled in remedial mathematics, while 16.2 percent of those who attended only a four-year college did so (table 3). One possible explanation for the lower remediation rate at four-year colleges is that Nevada recently discontinued funding to universities for providing remedial coursework. So, universities must now fund their remedial courses through their own budget, which has led to a decline in remedial courses available to students. For instance, at the University of Nevada, Las Vegas (UNLV), the percentage of students enrolled in remedial coursework declined from 37.7 percent in 2005 to 8.4 percent in 2006 (Nevada System of Higher Education 2007). Presumably, students who would have enrolled in a remedial course at UNLV now take their remedial courses concurrently at a community college while taking their college-level courses at UNLV (these students are shown as a separate category in table 3, as discussed below).

TABLE 3

Freshman mathematics remediation rates in Nevada public colleges and universities for the Nevada study population by type of college attended, 2006/07

Type of college	Total number of students	Percentage taking remedial courses
Four-year college only	2,486	16.2
Two-year college only	1,594	70.1
Both two-year and four-year college		
Four-year college only, fall 2006; two-year college only, spring 2007	68	70.6
Two-year college only, fall 2006; four-year college only, spring 2007	18	16.7
Simultaneous dual enrollment, courses primarily at a four-year college	406	41.1
Simultaneous dual enrollment, courses primarily at a two-year college	81	48.1

Source: Authors' analysis of 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

Table 3 also disaggregates students based on their patterns of postsecondary attendance when they attended both a two-year and a four-year college during the 2006/07 school year. Some students were enrolled in only one type of college at a time; these students were presumably transfer students from a four-year college to a two-year college (68 students) or from a two-year college to a four-year college (18 students). Some students were enrolled simultaneously at both a two-year and four-year college during the same semester. Table 3 organizes these students based on the type of institution at which they took the majority of their classes during the 2006/07 school year. Among the 406 students who took the majority of their courses at a four-year institution, the remediation rate was 41.1 percent. (Not shown in table 3, 30.5 percent of them took a remedial mathematics course at a two-year college.) Among the 81 students who took the majority of their courses at a two-year institution, the remediation rate was 48.1 percent.

Remediation rate by gender

The remediation rate was more than 10 percentage points higher for women (42.1) than for men (31.5; table 4).

TABLE 4

Freshman mathematics remediation rates in Nevada public colleges and universities for the Nevada study population by gender, 2006/07

Gender	Total number of students	Percentage taking remedial courses
Women	2,673	42.1
Men	1,980	31.5

Source: Authors' analysis of 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

Remediation rate by race/ethnicity

Asian students had the lowest remediation rate, at 28.5 percent, and White students had the second lowest rate, at 34.1 percent (table 5). Black

TABLE 5

Freshman mathematics remediation rates in Nevada public colleges and universities for the Nevada study population by race/ethnicity, 2006/07

Race/ethnicity	Total number of students	Percentage taking remedial courses
Black, not Hispanic	253	53.8
Hispanic	756	52.5
American Indian	46	47.8
White, not Hispanic	2,994	34.1
Asian	604	28.5

Note: Black includes African American, Hispanic includes Latino, Asian includes Native Hawaiian and Other Pacific Islander, and American Indian includes Alaskan Native.

Source: Authors' analysis of 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

students (53.8 percent) and Hispanic students (52.5 percent) were more likely to enroll in a remedial mathematics course than in a college-level mathematics course during their first year of college. American Indian students had a remediation rate of 47.8 percent. (Appendix A provides details of race/ethnicity by type of postsecondary institution and highest level of grade 12 mathematics completed.)

Remediation rate by adequate yearly progress status of high school attended

Under the No Child Left Behind Act of 2001 states annually assess students in grades 3–8 and once in high school using mathematics and reading/language arts tests aligned with state academic standards. All schools and districts receiving federal Title I funds must meet participation and performance requirements on these tests, as well as perform adequately on a state-determined additional indicator. All students must meet the same performance goals. If a school meets all these requirements, it is considered to have made "adequate yearly progress." The mathematics remediation rate during 2006/07 was higher for students who had attended schools that did not make adequate yearly progress (40.4 percent) compared with those who had attended schools that did (35.5 percent; table 6).

TABLE 6

Freshman mathematics remediation rate in Nevada public colleges and universities for the Nevada study population in 2006/07 by whether high school attended had made adequate yearly progress in 2005/06

High school made adequate yearly progress in 2006?	Total number of students	Percentage taking remedial courses
No	1,979	40.4
Yes	2,674	35.5

Source: Authors' analysis of data obtained from the Nevada Department of Education web site (Nevada Department of Education 2007); and 2006/07 data in the college coursework database , obtained by special permission from the Nevada System of Higher Education.

Remediation rate by locale of high school

The National Center for Education Statistics (NCES) defines the locale in which a school is located, from large city to rural area (for simplicity some of the NCES categories have been collapsed). The highest remediation rate (42.2 percent) was among students attending a school in an urban fringe, and the lowest rate (33.3 percent) was among students attending a school in a midsize city (table 7). In between, remediation rates ranged from 39.0 percent for students attending schools in towns to 35.5 percent for schools in rural locales, with schools in large cities at 36.5 percent.

CONCLUSION

The findings of this study may be useful to several groups in Nevada. For the Nevada System of Higher Education, which requested this analysis, the report quantifies the proportion of Nevada students who enrolled in the state's public colleges and universities directly from high school

TABLE 7

Freshman mathematics remediation rate in Nevada public colleges and universities for the Nevada study population in 2006/07 by locale of high school attended in 2005/06

Locale of high school attended	Total number of students	Percentage taking remedial courses
Urban fringe	1,473	42.2
Town	464	39.0
Large city	884	36.5
Rural	577	35.5
Midsize city	1,255	33.3

Note: Locales are defined by the National Center for Education Statistics: *large city*, principal city of a metropolitan core-based statistical area (CBSA), with a population of 250,000 or more; *midsize city*, principal city of a metropolitan CBSA, with a population of less than 250,000; *urban fringe* of a large city or midsize city, defined as urban by the Census Bureau; *town*, small or large, with a population of 2,500 or more and located outside a metropolitan CBSA or inside a micropolitan CBSA; and *rural* (outside or inside CBSA), defined as rural by the Census Bureau.

Source: Authors' analysis based on U.S. Department of Education, National Center for Education Statistics (2007) data; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

who were in need of mathematics remediation. It also identifies which mathematics courses these students completed in grade 12 and their grade 12 mathematics GPA. This report may also help parents, students, and educators better understand the likelihood that students completing particular mathematics courses in grade 12 will enroll in remedial mathematics courses before enrolling in college-level ones. This information can serve as a starting point for discussions between K–12 and college administrators about what should be considered adequate high school preparation.

This research is just a beginning. Access to students' full high school and college transcripts would enable a more complete analysis of college remediation rates by high school coursework. To improve predictions of the likelihood of remediation in college (for the logistic regression analysis detailed in appendix B), it would be helpful to have more detailed data on such student characteristics as socioeconomic status, English language learner status, and mathematics scores on standardized state-level tests, such as the High School Proficiency examination given to Nevada high school students. This could be done using a more detailed dataset, since having more extensive information on individual characteristics would enable better control for the possibility of selection bias.[10] In this regard, examination of the impact of taking higher level mathematics courses on students' ability to place out of remedial courses could be very important. Finally, future research could examine remediation patterns for English courses.

These and other research studies could help inform discussions among K–12 and college administrators about what should be considered adequate high school preparation. For instance, college administrators could examine the results of mathematics (or English) placement tests to find areas of difficulty for students and share this information with high schools. Educators might examine the placement tests and map the skills required for success in these tests against the skills taught in high school courses. High schools could use the information as they review the curriculum of courses found to have high remediation rates.

APPENDIX A
DATA SOURCES, METHODS, AND POPULATION

This appendix describes the data sources, methods, and population for this study.

Data sources

Data for this report were drawn from four sources: a Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; a Nevada System of Higher Education college coursework database, obtained by special permission from the Nevada System of Higher Education; the Common Core of Data *Public Elementary/Secondary School Universe Survey: School Year 2005/06* (U.S. Department of Education, National Center for Education Statistics 2007); and the Nevada Department of Education (2007), *2005–06 AYP*. Information about high school coursework was collected for all graduating seniors of the class of 2006 in Nevada high schools. Because the database was only recently implemented, it contained only the 2005/06 coursework. The Nevada System of Higher Education college transcripts were collected for all students who graduated from a Nevada high school in 2006 and enrolled in a Nevada public college or university in fall 2006 or spring 2007.

Data methods

This study calculated mathematics remediation rates based on the highest level of mathematics completed in grade 12 not only because grade 12 courses were the only ones included in the database for the cohort of students analyzed in this report but also because student performance in grade 12 has been shown to be highly correlated with student performance in other grades in high school (see Roderick and Camburn 1999; Riegle-Crumb 2006; and Cavanagh, Schiller, and Riegle-Crumb 2006).

Classification of the high school mathematics courses. The classification of high school mathematics courses in this report is based on the criteria developed by Burkam and Lee (2003), who developed an eight-level index to describe the highest level of mathematics completed by students: 1 = No mathematics, 2 = Nonacademic, 3 = Low academic, 4 = Middle I, 5 = Middle II, 6 = Advanced I, 7 = Advanced II, and 8 = Advanced III (see table A1 for a list of the courses for each category).

TABLE A1
Classification of high school mathematics courses

Level	Classification	Courses
1	No mathematics	None
2	Nonacademic	General 1 General 2 Basic 1 Basic 2 Basic 3 Consumer Technical Vocational Review
3	Low academic	Pre-algebra Algebra 1, part 1 Algebra 1, part 2 Geometry, informal
4	Middle I	Algebra 1 Geometry, plane Geometry, plane-solid Unified 1 Unified 2 Other Pure, other
5	Middle II	Algebra 2 Unified 3
6	Advanced I	Algebra 3 Algebra-trigonometry Algebra–analytical geometry Trigonometry Trigonometry–solid geometry Analytical geometry Linear algebra Probability Probability-statistics Statistics Statistics, other Independent study
7	Advanced II	Pre-calculus Introductory analysis
8	Advanced III	Calculus Advanced Placement calculus Calculus–analytical geometry

Source: Burkam and Lee 2003.

Following Burkam and Lee (2003), the current study is designed to capture the highest level of mathematics courses that students completed, not the highest level they attempted. Consequently, the variable indicating the highest level of mathematics completed is constructed from top to bottom. Students were assigned to Advanced III if they received a grade greater than or equal to pass, satisfactory, or D– for an Advanced III course, and so on down the list. Mathematics courses completed at a Nevada System of Higher Education college in a student's senior year of high school (fall 2005 or spring 2006) were counted as high school coursework.

Again, following the classification system of Burkam and Lee (2003), all mathematics courses in the dataset were classified twice, once by the authors of this report and once by a mathematics educator with more than 30 years of experience teaching mathematics at all levels and directing the mathematics curriculum at a large urban school district. Inter-rater reliability analysis showed high agreement (Kappa coefficient = 0.95), with agreement of more than 90 percent between the two sets of ratings for most levels (see table A2). Most discrepancies appeared in the less advanced categories. More specifically, the authors of this report tended to rate as Nonacademic some courses that the mathematics educator rated as being Low academic or Middle I. Where there was a discrepancy, the authors used the ratings of the high school mathematics educator for the analyses in this report. However, the overall results were similar regardless of which ratings system was used in the analysis.

Study questions and analysis. This study was guided by four questions:

- Which mathematics courses did Nevada students complete in grade 12, and how well did they do?
- What are the remediation rates for each level of mathematics courses that students completed in grade 12, and how do the rates differ by students' performance in these courses?
- How did the remediation rates differ based on other student characteristics—race/ethnicity, gender, and type of college attended (two-year, four-year, or combination)?
- How did the remediation rates differ by type of high school attended in grade 12, as measured by locale and by whether the school made adequate yearly progress that year under the No Child Left Behind Act of 2001?

The initial dataset included the grade 12 and college freshman year transcripts of students who graduated from a Nevada public high school in 2006 and enrolled in a Nevada System of Higher

TABLE A2

Share of courses in agreement between two classification ratings of mathematics courses, 2005/06 (percent)

Classification by researchers	Classification by mathematics educator						
	Nonacademic	Low academic	Middle I	Middle II	Advanced I	Advanced II	Advanced III
Nonacademic	79.7	10.5	9.0	0.8	0.0	0.0	0.0
Low academic	4.0	91.5	4.3	0.2	0.0	0.0	0.0
Middle I	0.0	7.2	92.8	0.0	0.0	0.0	0.0
Middle II	0.0	0.0	0.2	99.8	0.0	0.0	0.0
Advanced I	0.0	1.6	1.7	0.0	96.7	0.0	0.0
Advanced II	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Advanced III	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Source: Authors' and mathematics educator's analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education.

Education institution in either fall 2006 or spring 2007. Of this population of 8,264 students, 3,611 students were excluded from the analysis because they did not enroll in any mathematics courses in college during the period under observation. These students were excluded because it could not be determined whether they would eventually enroll in remedial mathematics in college. Also left out of the sample were students who took a mathematics course in grade 12 in 2005/06 but did not attend college or who did not attend a college within the Nevada System of Higher Education in 2006/07. The final study population of 4,653 students consisted of all students who graduated from a Nevada high school in 2006 and enrolled in at least one mathematics course in a Nevada public college or university in 2006/07.

Descriptive analyses were conducted to determine the highest level of mathematics that students completed in grade 12 and the grade point average (GPA) for their grade 12 mathematics courses. A student's grade 12 mathematics GPA was calculated by averaging all grades earned in mathematics courses during grade 12, to get a sense of how well a student did in grade 12 mathematics, even when some students (15.0 percent) took different levels of mathematics that year.

Next, remediation rates of students were calculated based on student characteristics such as highest level of mathematics completed in grade 12, grade 12 mathematics GPA, gender, race/ethnicity, and whether the student enrolled in a two-year or four-year institution. Remediation rates of students were also calculated based on characteristics of the high schools they attended: whether the school made adequate yearly progress in 2006 and school locale.

Multivariate analysis was also conducted to examine the correlation between mathematics remediation status and various student characteristics (see appendix B). The multivariate analysis isolates the relationship between a given student characteristic (such as highest mathematics level completed in grade 12) and remediation status, while controlling for other student characteristics (such as gender and race/ethnicity). The results of this analysis confirm the findings of the descriptive statistics.

Overview of the study population

The study population was the total population of Nevada high school graduates in 2006 who enrolled in at least one mathematics course in college (two-year or four-year) in either fall 2006 or spring 2007. Because the study analyzes the entire population of Nevada high school graduates who took a mathematics course during their freshman year at a Nevada System of Higher Education institution, this research does not report tests of statistical significance, which are commonly used only when analyzing data from a sample of a population.

Female students (57.4 percent) and White students (64.4 percent) make up a majority of this population of 4,653 students (table A3). The next largest racial/ethnic group is Hispanic students

TABLE A3
Distribution of Nevada study population by gender and race/ethnicity, 2006/07

Gender and race/ethnicity	Number of students	Share of total (percent)
Gender		
Women	2,673	57.4
Men	1,980	42.6
Total	4,653	100.0
Race/ethnicity		
White, not Hispanic	2,994	64.4
Hispanic	756	16.2
Asian	604	13.0
Black, not Hispanic	253	5.4
American Indian	46	1.0
Total	4,653	100.0

Note: Black includes African American, Hispanic includes Latino, Asian includes Native Hawaiian and Other Pacific Islander, and American Indian includes Alaskan Native.

Source: Authors' analysis of 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

TABLE A4

Distribution of Nevada study population by adequate yearly progress status of high school attended in 2005/06

High school made adequate yearly progress in 2006?	Number of students	Share of total (percent)
Yes	2,674	57.5
No	1,979	42.5
Total	4,653	100.0

Source: Authors' analysis based on data from Nevada Department of Education (2007) and 2005/06 grade 12 transcript data in the high school coursework database, obtained by special permission from the Nevada Department of Education.

TABLE A5

Distribution of Nevada study population by locale of high school attended, 2005/06

Locale of high school attended	Number of students	Share of total (percent)
Urban fringe	1,473	31.7
Midsize city	1,255	27.0
Large city	884	19.0
Rural	577	12.4
Town	464	10.0
Total	4,653	100.0

Note: Locales are defined by the National Center for Education Statistics as follows: *large city*, principal city of a metropolitan core-based statistical area (CBSA), with a population of 250,000 or more; *midsize city*, principal city of a metropolitan CBSA, with a population of less than 250,000; *urban fringe* of a large city or midsize city, defined as urban by the Census Bureau; *town*, small or large, with a population of 2,500 or more and located outside a metropolitan CBSA or inside a micropolitan CBSA; and *rural* (outside or inside CBSA), defined as rural by the Census Bureau.

Source: Authors' analysis based on data from U.S. Department of Education, National Center for Education Statistics (2007) and 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education.

(16.2 percent), followed by Asian (13.0 percent), Black (5.4 percent), and American Indian (1.0 percent) students.

The majority of students in this population (57.5 percent) attended a high school that made adequate yearly progress in 2006 (table A4).

Almost a third of the students in this population (31.7 percent) attended a high school in an urban fringe of a city, while the smallest share (10.0 percent) attended a high school in a town (table A5). More than a quarter of students (27.0 percent) attended a high school in a midsize city.

Table A6 shows remediation rates by race/ethnicity, type of postsecondary institution attended (two-year college, four-year college, or both), and the highest mathematics course completed in grade 12. This table shows whether there are differences in remediation rates between, for instance, Black students who completed Advanced I mathematics and attended a four-year college only, as compared to Black students who completed Advanced I mathematics and attended a two-year college only.

Nevada System of Higher Education institutional placement procedures

While each Nevada System of Higher Education institution has its own practices for assigning students to remedial mathematics courses, test scores for placing students into a remedial course are similar across institutions (table A7).

TABLE A6

Freshman remediation rates in Nevada public colleges and universities for Nevada study population by race/ethnicity, by postsecondary institutional type attended, and by the highest mathematics course completed in grade 12

Race/ethnicity	Type of college enrolled in	Highest level of mathematics completed in grade 12	Total number enrolled	Percentage taking remedial course
Asian	Four-year college only	No mathematics	67	13.4
		Nonacademic	0	0.0
		Low academic	0	0.0
		Middle I	8	62.5
		Middle II	20	45.0
		Advanced I	83	8.4
		Advanced II	77	6.5
		Advanced III	99	1.0
	Two-year college only	No mathematics	46	58.7
		Nonacademic	1	100.0
		Low academic	2	100.0
		Middle I	21	81.0
		Middle II	37	81.1
		Advanced I	31	58.1
		Advanced II	22	22.7
		Advanced III	2	100.0
	Both two-year and four-year college	No mathematics	16	37.5
		Nonacademic	0	0.0
		Low academic	0	0.0
		Middle I	2	50.0
		Middle II	10	80.0
		Advanced I	22	54.6
		Advanced II	27	25.9
		Advanced III	11	18.2
Black, not Hispanic	Four-year college only	No mathematics	40	20.0
		Nonacademic	1	0.0
		Low academic	0	0.0
		Middle I	7	71.4
		Middle II	14	42.9
		Advanced I	35	37.1
		Advanced II	26	7.7
		Advanced III	8	0.0
	Two-year college only	No mathematics	17	100.0
		Nonacademic	1	100.0
		Low academic	1	100.0
		Middle I	32	93.8
		Middle II	27	88.9
		Advanced I	14	85.7
		Advanced II	9	33.3
		Advanced III	0	0.0

(CONTINUED)

TABLE A6 (CONTINUED)

Freshman remediation rates in Nevada public colleges and universities for Nevada study population by race/ethnicity, by postsecondary institutional type attended, and by the highest mathematics course completed in grade 12

Race/ethnicity	Type of college enrolled in	Highest level of mathematics completed in grade 12	Total number enrolled	Percentage taking remedial course
Black, not Hispanic (continued)	Both two-year and four-year college	No mathematics	3	100.0
		Nonacademic	1	0.0
		Low academic	0	0.0
		Middle I	2	50.0
		Middle II	6	100.0
		Advanced I	5	80.0
		Advanced II	3	0.0
		Advanced III	1	0.0
Hispanic	Four-year college only	No mathematics	76	22.4
		Nonacademic	2	100.0
		Low academic	0	0.0
		Middle I	22	68.2
		Middle II	31	35.5
		Advanced I	67	11.9
		Advanced II	74	9.5
		Advanced III	48	4.2
	Two-year college only	No mathematics	86	70.9
		Nonacademic	2	100.0
		Low academic	10	90.0
		Middle I	98	88.8
		Middle II	80	86.3
		Advanced I	49	77.6
		Advanced II	24	62.5
		Advanced III	4	25.0
	Both two-year and four-year college	No mathematics	20	55.0
		Nonacademic	0	0.0
		Low academic	1	100.0
		Middle I	17	82.4
		Middle II	14	64.3
		Advanced I	18	72.2
		Advanced II	11	45.5
		Advanced III	2	0.0
White, not Hispanic	Four-year college only	No mathematics	540	24.3
		Nonacademic	4	75.0
		Low academic	6	50.0
		Middle I	41	51.2
		Middle II	93	35.5
		Advanced I	384	14.1
		Advanced II	306	5.2
		Advanced III	289	1.4

(CONTINUED)

TABLE A6 (CONTINUED)

Freshman remediation rates in Nevada public colleges and universities for Nevada study population by race/ethnicity, by postsecondary institutional type attended, and by the highest mathematics course completed in grade 12

Race/ethnicity	Type of college enrolled in	Highest level of mathematics completed in grade 12	Total number enrolled	Percentage taking remedial course
White, not Hispanic (continued)	Two-year college only	No mathematics	419	67.1
		Nonacademic	16	87.5
		Low academic	25	88.0
		Middle I	129	83.7
		Middle II	133	67.7
		Advanced I	141	61.0
		Advanced II	74	39.2
		Advanced III	20	15.0
	Both two-year and four-year college	No mathematics	184	33.2
		Nonacademic	2	100.0
		Low academic	2	0.0
		Middle I	11	81.8
		Middle II	27	55.6
		Advanced I	63	34.9
		Advanced II	50	26.0
		Advanced III	35	2.9

Note: Black includes African American, Hispanic includes Latino, and Asian includes Native Hawaiian and Other Pacific Islander. Because of the small sample size of American Indian students (46), this subgroup is not reported. The small sample size resulted in many of the cells in the table being zero. This information is available from the authors on request.

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

TABLE A7

Nevada System of Higher Education institutional placement procedures for remedial mathematics courses

Institution	Remedial course number	Placement method
University of Nevada, Reno	Math 096	• ACT Math score < 21 • SAT Math score < 500 • BART institutional test for Math 120/124
University of Nevada, Las Vegas	Math 095 Math 096	• ACT score < 20 • SAT score < 500 • ACT score 20 • SAT score 500–509
Nevada State College	Math 093 Math 095 Math 096	• Math Placement Test score < 9 • Math Placement Test score 10–14; ACT score < 20; SAT score < 500 • Math Placement Test score 15–17; ACT score of 20; • SAT score of 500–519
Community College of Southern Nevada	Math 091 Math 093 Math 095 Math 096 Math 097	• Accuplacer Arithmetic 0–50 • Accuplacer Arithmetic > = 50 and Elementary Algebra < 34 • Accuplacer Elementary Algebra > = 34 and < 82 or ACT = 17 or SAT = 400 • Accuplacer Elementary Algebra > = 82 and College Level Math < 55 or ACT = 19 or SAT = 500 • Accuplacer Elementary Algebra > = 34 and < 82 or ACT = 18 or SAT = 470
Great Basin College	Math 091 Math 095 Math 096	• ACT score < 16 • Recentered SAT score < 480 • CPT arithmetic score < 86 • ACT score < 16–17 • Recentered SAT score 480–499 • CPT arithmetic score > 86 • CPT elementary algebra score > 63 • ACT score 18–20 • Recentered SAT score 500–530 • CPT arithmetic score >86 • CPT elementary algebra score 63–82.9
Truckee Meadows Community College	Math 091 Math 093 Math 095 Math 096	• Self-select or Accuplacer Arithmetic 0–30 • Accuplacer Arithmetic 31–120 • Accuplacer Elementary Algebra 32–52 • Accuplacer Elementary Algebra 53–79
Western Nevada Community College	Math 090 Math 091 Math 093 Math 095 Math 095 Math 096 Math 090/091 Math 093 Math 093 Math 095 Math 096	• MAPS Applied Arithmetic – Level I – 0–16 • MAPS Applied Arithmetic – Level I – 17–22 • MAPS Applied Arithmetic – Level I – 23–25 • MAPS Applied Arithmetic – Level I – 26 or more • MAPS Elementary Algebra – Level II – 18 or less • MAPS Elementary Algebra – Level II – 19 or more • Accuplacer Arithmetic Test – 62 or less • Accuplacer Arithmetic Test – 63 or more • Accuplacer Elementary Algebra Test – 38 or less • Accuplacer Elementary Algebra Test – 39–52 • Accuplacer Elementary Algebra Test – 53–120

Note: SAT is Scholastic Assessment Test; BART is Basic Algebra Readiness Test; CPT is College Placement Test; MAPS is Descriptive Tests of Mathematics Skills.

Source: Nevada System of Higher Education 2007.

APPENDIX B
LOGISTIC REGRESSIONS

This appendix reports the results of a logistic regression model used to examine the relation between student characteristics and the college mathematics remediation rate.

The descriptive statistics in the body of this report present the remediation rates for various subpopulations of students as a relation between two variables, such as gender and remediation. (Figure 3, which presents the relationship between three variables, is an exception.) These bivariate relationships may not provide the complete story, however. Thus, while the results show that women were more likely on average than men to enroll in remedial mathematics, this may not be the entire story. For example, the difference might be partially explained by differences in the highest level of mathematics completed in grade 12 by men and women or by differences in grade 12 mathematics grade point averages (GPAs).

Examining multiple factors simultaneously requires conducting multivariate analysis. By "controlling" for these other variables, multivariate analysis essentially holds them constant. In the gender example, multivariate analysis allows comparing remediation rates for a male student and a female student who have both completed the same highest level of grade 12 mathematics, have the same grade 12 mathematics GPA, are of the same race/ethnicity, and have enrolled in the same type of college.

The logistic regression used in this analysis examines the relationship between mathematics remediation status and the following student-level characteristics: the highest level of mathematics taken in grade 12, grade 12 mathematics GPA, gender, race/ethnicity, and the type of college that the student enrolled in (two-year, four-year, or both). Odds ratios are estimated, comparing the odds of enrolling in remediation between two different groups (such as men and women) while controlling for other student-level characteristics.

Methodology

A logistic regression was estimated using the same sample of students as in the descriptive analysis. The logistic regression model was as follows:

$$(1)\quad REMEDIATION_i = \beta_1\mathbf{COURSE}_i + \beta_2\mathbf{GPA}_i + \beta_3 GENDER_i + \beta_4\mathbf{ETHNICITY}_i + \beta_5\mathbf{COLLEGE}_i + \varepsilon_i$$

where $REMEDIATION_i$ is college mathematics remediation status, $\mathbf{COURSE}_i$ is a vector of binary indicator variables for the highest mathematics level completed in grade 12, $\mathbf{GPA}_i$ is a vector of binary indicator variables for grade 12 mathematics GPA, $GENDER_i$ is an indicator variable for gender, $\mathbf{ETHNICITY}_i$ is a vector of binary indicator variables for the ethnicity of the student, $\mathbf{COLLEGE}_i$ is a vector of binary indicator variables for the type of college that the student enrolled in, and ε_i is the error term. The subscript i pertains to student i. β_1 through β_5 are the odds ratios estimated from the data. For instance, β_1 is a vector of odds ratios that pertain to the vector of binary indicator variables for $\mathbf{COURSE}_i$.

The probability that a student takes a remedial mathematics course in college is modeled using the following logit link:

$$(2)\quad \Pr(y_i = 1) = \text{logit}^{-1}(\mathbf{X}_i\beta)$$

where y_i is remediation status, $\mathbf{X}_i$ is a vector of student-level characteristics, and β is a vector of odds ratios to be estimated from the data. The function $\text{logit}^{-1}(z) = e^z/(1+e^z)$ transforms continuous values to the range (0,1) and is used because the dependent variable (remediation status) is binary.

Odds ratios rather than coefficients are reported here for ease of interpretation. If two outcomes have the probabilities (p, 1–p), then $p/(1-p)$ is called the odds. The ratio of two odds, such as that for men (p_1) and that for women (p_2)—thus, $[p_1/(1\text{-}p_1)]/[p_2/(1-p_2)]$—is called the odds ratio. Suppose that the probability that a man is enrolled

in remediation is 40 percent and the probability that a woman is enrolled in remediation is 50 percent (which is estimated after controlling for other student-level characteristics in the logistic regression). The odds ratio would then be [.4/(1–.4)]/[.5/(1–.5)] 0.667. This would mean that the odds of enrolling in remedial mathematics for men is .333 less (1–0.667) than those for women, holding all other variables included in the model constant. If the odds ratio between men and women were 1, then both men and women would have the same odds of enrolling in remedial mathematics. An odds ratio greater than 1 means that the group has higher odds than the comparison group, while an odds ratio of less than 1 means that the group has lower odds than the comparison group.

Results of the logistic regression

Table B1 reports the odds ratios and standard errors of a logistic regression in which the dependent variable is college mathematics remediation status (yes/no) and the independent variables include a number of student-level characteristics.[11] To include the full sample of 4,653 students, the continuous GPA variable was recoded into a series of indicator variables. The grade 12 mathematics GPA was rounded to the nearest third on a four-point scale (0.00, 0.33, 0.67, 1.00, 1.33, 1.67, 2.00, 2.33, 2.67, 3.00, 3.33, 3.67, and 4.00). Dummy indicators were then created for each of the 13 values, with the 14th dummy indicator representing students with a missing grade 12 mathematics GPA. GPA was coded in this way so as to include in the logistic regression students who did not take or complete a mathematics course in grade 12.

In the logistic regression model the omitted categories are White female students whose highest mathematics course was in Advanced I, whose grade 12 mathematics GPA was 4.0, and who matriculated to a four-year college. Estimates of the standard errors allow for intragroup correlation, whereby observations within the same high schools may be correlated (commonly referred to as a robust estimator of variance). Students who attend the same high schools are likely to be similar, which would mean that the error term is not independent and identically distributed (iid). Because the iid assumption is violated, robust standard errors are estimated.

The Advanced I course level was omitted from the model as the comparison group. The odds ratio for Nonacademic mathematics courses is 8.746, meaning that students completing Nonacademic mathematics courses in grade 12 have 8.746 times (874.6 percent) the odds of remediation as students completing Advanced I mathematics, controlling for gender, race/ethnicity, mathematics GPA in grade 12, and type of college attended. This difference is statistically significant at the 5 percent level meaning that the difference in observed odds of remediation between these two groups of students is unlikely to have happened by chance.[12] For students who completed Low academic courses, the odds of remediation are 5.639 times (563.9 percent) as large as those for students who completed Advanced I courses, and this difference is statistically significant at the 5 percent level. For students who completed Middle I or Middle II mathematics courses the odds of remediation are also larger than those for students who completed Advanced I courses, and these differences are statistically significant at the 5 percent level. For Middle II mathematics the difference in the odds of remediation are more than two times those for Advanced I courses, even though Advanced I is only one level higher, even after controlling for student demographics and grade 12 mathematics GPA.

For students who completed higher level courses the odds of remediation are considerably lower than for those who completed Advanced I courses. For students who completed Advanced II mathematics courses in grade 12 the odds of remediation are 0.383 times those for students who completed Advanced I, and this difference is statistically significant at the 5 percent level. For students who completed Advanced III mathematics the odds of remediation are a tenth (0.101) those for students who completed Advanced I mathematics, and this difference is statistically significant at the 5 percent level.

TABLE B1

Results from the logistic regression in which the dependent variable is college mathematics remediation status

Student characteristics	Odds ratio (standard error)
No mathematics	1.023
	(2.388)
Nonacademic	8.746***
	(7.129)
Low academic	5.639***
	(2.932)
Middle I	5.153***
	(0.942)
Middle II	2.406***
	(0.435)
Advanced II	0.383***
	(0.078)
Advanced III	0.101***
	(0.032)
Average GPA = 0.0	3.293
	(7.729)
Average GPA = 0.33	1.922
	(1.669)
Average GPA = 0.67	3.675***
	(1.430)
Average GPA = 1.0	3.759***
	(0.969)
Average GPA = 1.33	2.168*
	(0.887)
Average GPA = 1.67	2.787***
	(0.630)
Average GPA = 2.0	3.029***
	(0.630)
Average GPA = 2.33	2.951***
	(1.083)
Average GPA = 2.67	2.419***
	(0.469)
Average GPA = 3.0	1.646***
	(0.267)
Average GPA = 3.33	1.554**
	(0.315)
Average GPA = 3.67	1.265
	(0.236)
Average GPA = missing	2.605
	(6.077)
Two-year college only	7.441***
	(1.330)
Dual enrollment (two-year and four-year)	3.103***
	(0.668)
Male	0.587***
	(0.046)
Hispanic	1.505***
	(0.184)
Black, not Hispanic	1.842***
	(0.391)
Asian	0.954
	(0.119)
American Indian	1.452
	(0.578)
Number of observations	4,653

* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

Thus, students who completed a level of mathematics below Advanced I were more likely to enroll in remedial college mathematics courses than students who completed Advanced I, while students who completed a level of mathematics above Advanced I were less likely to enroll in such courses. With the exception of students who completed no mathematics courses, the odds ratios are monotonically decreasing for students taking more-advanced mathematics courses. This result is expected, in that students who completed Low academic mathematics had higher odds ratios than students who completed Middle I courses, who in turn had higher odds ratios than

students who completed Middle II courses, and so on.

Table B1 also reports the relationship between grade 12 mathematics GPA and college mathematics remediation status. In this model the omitted comparison group was students who earned a GPA of 4.0. The table shows, for example, that for students who earned a grade 12 mathematics GPA of 0.67, the odds of remediation was 3.675 times (367.5 percent) that of students who earned a 4.0 GPA, controlling for gender, race/ethnicity, highest mathematics course completed in grade 12, and type of college enrolled in. This difference is statistically significant at the 5 percent level. The odds ratios for students with grade 12 mathematics GPAs of 0.67, 1.0, and 1.67 through 3.33 are all statistically significant at the 5 percent level. The odds ratios for students with a GPA of 3.67, though greater than one, is not statistically significant, meaning that the difference in remediation status between students earning a 3.67 and a 4.0 could be due to chance. The odds ratio for students with a GPA of 1.33 is statistically significant at the 10 percent level, but not at the 5 percent level.

The logistic regressions included the type of college in which a student enrolled after graduating from high school in Nevada. The omitted comparison group for this model is students who attended a four-year college only during the 2006/07 school year. Table B1 shows that for students enrolling only in a two-year college the odds of remediation are 7.441 times (744.1 percent) those for students enrolling only in a four-year institution and that this difference is statistically significant at the 5 percent level. Similarly, for students enrolling in both a two-year and four-year college, the odds of remediation are 3.103 times as large as those for students who enrolled only in a four-year institution, a difference that is statistically significant at the 5 percent level.

Table B1 also shows that male students have lower odds of being enrolled in remedial mathematics as college freshmen than female students do. Specifically, for male students the odds of mathematics remediation were 0.587 times (or 41.3 percent less than) that for female students, even after controlling for race/ethnicity, the highest level of mathematics completed in grade 12, and grade 12 mathematics GPA. This odds ratio is statistically significant at the 5 percent level.

For student race/ethnicity the comparison group in the model is White students. For Hispanic students the odds of remediation are 1.505 times (150.5 percent) those for White students, controlling for other student characteristics included in the model. This difference is statistically significant at the 5 percent level. For Black students the odds of remediation are 1.842 times those for White students and are statistically significant at the 5 percent level. For American Indian students the odds of remediation are 1.452 times those for White students, but this difference is not statistically significant at the 5 percent level. Finally, for Asian students the odds of remediation are 0.954 times those for White students, a difference that is not statistically significant at the 5 percent level.

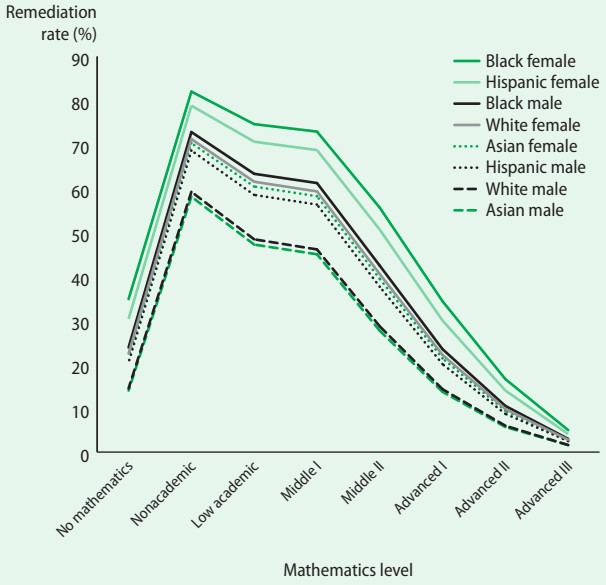
Predicted probabilities

This section uses the calculations from the logistic regression to derive predicted probabilities of the remediation rate, given a particular set of personal characteristics, for example, the probability of remediation for a Hispanic male student with a grade 12 mathematics GPA of 2.7, whose highest level of mathematics completed was Advanced I, and who enrolled in a four-year college. Coefficients from the logistic regression are applied to such specified student-level characteristics to derive predicted probabilities. Predicted probabilities are between 0 and 100 percent.

Results of predicted probabilities for various combinations of gender and race/ethnicity are presented in figure B1, holding certain student characteristics constant: that the students had a grade 12 mathematics GPA of 2.7 and enrolled in a four-year institution.

FIGURE B1

Predicted probabilities of college remedial mathematics for various race/ethnicities and gender, holding grade 12 mathematics grade point average and enrollment in four-year college constant



Note: Black includes African American, Hispanic includes Latino, and Asian includes Native Hawaiian and Other Pacific Islander.

Source: Authors' analysis of 2005/06 grade 12 transcript data in the Nevada high school coursework database, obtained by special permission from the Nevada Department of Education; and 2006/07 data in the college coursework database, obtained by special permission from the Nevada System of Higher Education.

Among students whose highest level of grade 12 mathematics was Nonacademic, the predicted probability that a Black female student enrolls in college remedial mathematics is approximately 81 percent (given that the student had a grade 12 mathematics GPA of 2.7 and enrolled in a four-year college). The predicted probability is approximately 78 percent for Hispanic female students, 72 percent for Black male students, 71 percent for White female students, 71 percent for Asian female students, and so on.

As figure B1 also shows, for any gender-ethnicity combination the predicted probability of remediation decreases from Nonacademic courses through Advanced III courses. These results are similar to those for the descriptive statistics in the body of the report, which related general remediation rates to the level of mathematics completed in high school (see table 2 in main report).

Figure B1 also illustrates a steep decline in the predicted probability of college remediation for students who completed Middle I courses compared with students who completed Advanced I courses. Among Black male students, for instance, the predicted probability of remediation drops approximately 19 percentage points between Middle I and Middle II courses (from 61 percent to 42 percent) and another 19 percentage points between Middle II and Advanced I courses (from 42 percent to 23 percent), or more than 35 percentage points between students taking levels that are two units apart.

Overall, then, the results in this section generally confirm the findings of the descriptive statistics in the body of the report. The chances of remediation drop steeply with an increase in the level of the grade 12 mathematics courses, even after controlling for grade 12 mathematics GPA, type of college attended, gender, and race/ethnicity.

NOTES

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1. Nevada System of Higher Education institutions include the University of Nevada, Las Vegas; the University of Nevada, Reno; Nevada State College; Community College of Southern Nevada; Great Basin College; Truckee Meadows Community College; Western Nevada Community College; and Desert Research Institute.

2. These costs are the expenses incurred for delivering the remedial courses and do not include the offsetting revenue earned from tuition for these courses.

3. Also excluded from the original dataset were students who never attended college, students who delayed postsecondary education, and students who attended a college outside the Nevada System of Higher Education. To the extent that students who matriculate to an out of state university differ from those who matriculate to a Nevada System of Higher Education institution, the results in this report must be interpreted with caution. Also, students who delay postsecondary enrollment after high school may be different from the population analyzed in this report. If less academically inclined students are more likely to delay enrollment in postsecondary education, as some research suggests (see Hearn 1992; Horn, Cataldi, and Sikora 2005; Rowan-Kenyon 2007), and if the study population were to include all students who enrolled in a Nevada System of Higher Education institution after high school, even after some delay, calculations of the overall remediation rates would likely rise. For instance, Rowan-Kenyon (2007) finds that the odds of enrolling in college immediately after high school graduation rather than delaying enrollment increased with the level of mathematics completed in high school.

4. For further discussion on causal inference, see Pearl (2000); Shaddish, Cook, and Campbell (2002); Holland (1986); Campbell (1969); Campbell and Stanley (1963).

5. Because the study analyzes the entire population of Nevada high school graduates who took a mathematics course during their freshman year at a Nevada System of Higher Education institution, this research does not report tests of statistical significance, which are commonly used only when analyzing data from the sample of a population.

6. When a mathematics level is mentioned by name it refers to the highest mathematics level completed by a student in grade 12.

7. Further analysis shows that most students in the No mathematics category (1,481 of the 1,536 students, or 96.4 percent) did not enroll in a mathematics course in grade 12. Of the remaining 55 students (based on the highest course they attempted and failed): 1 student failed Low academic, 4 students failed Middle I, 8 students failed Middle II, 18 students failed Advanced I, 20 students failed Advanced II, and 4 students failed Advanced III.

8. In a small number of cases students took different mathematics courses in the fall and spring semesters. For students whose highest level of mathematics was Advanced III, for instance, the grade 12 mathematics GPA may include coursework completed in a lower level.

9. The Nonacademic and Low academic categories are not included in this analysis because of the small sample sizes of students within each GPA cell in these two categories. There

were 30 students in total in the Nonacademic category and 47 students in the Low academic category. In addition, there were fewer students across all courses that averaged a D (1.0) GPA in the sample, so the remediation rates plotted in figure 3 for students averaging a 1.0 GPA may be unstable. Specifically, there were 39 students with a 1.0 GPA for Middle I, 57 for Middle II, 88 for Advanced I, 64 for Advanced II, and 27 for Advanced III. For this reason, there is no discussion of students with a 1.0 average. With regard to the other sample sizes in this figure, for Middle I there were 100 students with GPAs of 2.0, 118 with GPAs of 3.0, and 136 with GPAs of 4.0. For Middle II there were 143 students with GPAs of 2.0, 173 with GPAs of 3.0, and 122 with GPAs of 4.0. For Advanced I there were 233 students with GPAs of 2.0, 352 with GPAs of 3.0, and 250 with GPAs of 4.0. For Advanced II there were 198 students with GPAs of 2.0, 282 with GPAs of 3.0, and 164 with GPAs of 4.0. Finally, for Advanced III there were 80 students with GPAs of 2.0, 189 with GPAs of 3.0, and 225 with GPAs of 4.0.

10. To estimate the average effect of receiving a treatment (higher level mathematics courses), the assumption that the treatment satisfies some form of exogeneity must be satisfied. Different versions of this assumption are referred to in the literature as "unconfoundedness," "selection on observables," and "conditional independence." This assumption implies that receipt of treatment is independent of potential outcomes with and without treatment if certain observable characteristics are controlled for. It follows that controlling for a greater number of characteristics related to treatment status and potential outcomes would make this assumption more plausible.

11. A model was also estimated in which school-level characteristics were included with the student-level characteristics. The school-level characteristics were school enrollment, locale, percentage of students qualifying for free or reduced-price lunch, and an indicator for whether the school made adequate yearly progress. The model was run hierarchically, with students nested within schools. There were random coefficients for gender and race/ethnicity and an overall school random intercept. With the exception of students from an urban fringe school being more likely to enroll in remediation than students from a large city school, none of the school-level characteristics were statistically significant at the 5 percent level. Moreover, the sign and statistical significance of each of the student-level variables did not change. For ease of interpretation of the results of this report, these results are not presented.

12. Statistical significance in the text is reported for relationships that are statistically significant at the 5 percent level. Table B1 reports statistical significance at the 10, 5, and 1 percent levels. Relationships reported to be significant at the 1 percent level in table B1 are also statistically significant at the 5 percent level.

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