Hungry for Success? SNAP Timing, High-Stakes Exam Performance, and College Attendance

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Abstract

Monthly government transfer programs produce cycles of consumption that track benefit receipt, creating periods in which many households experience food insecurity. In this paper, we exploit state-level variation in the staggered timing of nutritional assistance benefit issuance across households to analyze how this monthly cyclicality in food availability affects academic achievement. Using individual-level score data from a large national college entrance exam in the United States linked to national college enrollment data, we find that taking this high-stakes exam in the last two weeks of the SNAP benefit cycle reduces test scores and lowers the probability of attending a 4-year college for low-income high school students.

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1 Introduction

There is a strong link between income inequality and nutritional inequality. More than 35 percent of families under the federal poverty line are food insecure, compared to less than 10 percent for those with incomes more than three times the federal poverty line (Schanzenbach, Bauer, and Nantz, 2016). This inequality extends to and perhaps perpetuates inequality in human capital accumulation. Low socioeconomic status (SES) students perform increasingly worse on tests relative to their higher-income peers, exacerbating gaps in high-school completion and college attendance (Reardon, 2011).

To measure the extent to which nutritional deficiencies affect human capital and productivity, we exploit a natural experiment in the timing of nutritional assistance benefits. The federal Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) provides food-purchasing assistance to 41 million Americans each year, and US states have authority to determine their own distribution schedules. Recent studies have shown that households increase the quantity and quality of food expenditures right after SNAP receipt and subsequently decrease consumption, creating a "calorie crunch" just before their next disbursement (Shapiro, 2005; Kuhn, 2018; Tarasuk, McIntyre, and Li, 2007; Castner and Henke, 2011; Todd, 2015; Laurito and Schwartz, 2019). A number of states use the first letter of a family's surname to determine its monthly disbursement date. By matching the SNAP schedules from 8 states with the administration dates of the SAT, a high-stakes exam used for college admission decisions in the United States, we then isolate quasi-random variation in the nutritional quality of exam takers. Since the SAT date varies from year to year, we are able to measure effects across cohorts, states, and years. In this paper, we use this variation to estimate effects of nutritional deficits on academic achievement.

Using detailed, individual-level data on SAT scores and college attendance, we find that low-income students who sit for the exam two weeks after their assigned SNAP issuance date score around 6 points, or 0.06 standard deviations, lower than those who sit in the two weeks following disbursement.[1] We also find some evidence that low-income students scoring comparatively lower on their SAT are 0.7 percentage points less likely to attend a 4-year college, and those who do

[1] We note that these effects are smaller than the standard error of measurement calculated by the College Board (approximately 32 points), but fit within the from 0.002–0.3 standard deviations range of estimates of related SAT interventions, discussed in further detail below.

attend college attend lower-quality, less-selective universities. Because we are not able to directly link students receiving SNAP to those taking the SAT exam, we note that these effects are intent-to-treat estimates and represent a lower bound of the effects of nutritional deficiencies on student achievement. Even so, we estimate in our subset of 8 states that this performance loss results in around 1100 students not attending a 4-year college.

Importantly, we note that nutritional deficiencies affect not just the SAT, but other high-stakes tests, implying that these findings speak to the gaps in educational attainment more broadly. Moreover, our results shed light on a possible benefit of an optimally run in-kind food transfer program on cognitive performance and human capital accumulation. They also provide a plausible estimate of the effect of smoothing SNAP issuance throughout the month, a low-cost policy intervention. This is especially important in light of the fact that food insecurity may continue after high school into adulthood.[2] Finally, they provide a new causal estimate of the effect of food insecurity on productivity, as measured by cognitive test performance.

We note that our findings expand on and contribute to the current literature in a number of ways. Importantly, we build on a body of work showing that short-run environmental and psychological shocks, including sleep, temperature, pollution, local violence, and stress, can affect students' cognitive performance, to provide new evidence of the effects of nutritional shocks on academic achievement and longer-run outcomes.[3] Previous research on the relationship between nutritional quality and educational outcomes has generally focused on long-term measures of food security or program participation, rather than the causal effect of immediate nutrition.[4] While there is some

[2]For example, less than half of college students eligible for SNAP participated in 2016, and an estimated half of students struggle with food insecurity (Broton and Goldrick-Rab, 2017; Freudenberg, Goldrick-Rab, and Poppendieck, 2019; Office, 2018).

[3]In particular, Alhola and Polo-Kantola (2007) provides a literature review showing sleep deprivation impairs attention and long-term memory. Zivin, Hsiang, and Neidell (2017) finds that changing the temperature 10 degrees Celsius decreases math scores by 0.12 standard deviations, while Garg, Jagnani, and Taraz (2019) finds that high temperatures similarly reduce math and reading scores. Ebenstein, Lavy, and Roth (2016) uses data on Israeli students and finds that a 10-unit increase in PM2.5 exposure decreases student performance by 0.083 standard deviations, lowers educational attainment by 3 percentage points and earnings by 2.1 percent. Chang and Padilla-Romo (2019) use data from Mexico and determine that exposure to nearby violent crime the week before a high-stakes test reduces test scores for female students (but not male students) by 0.11 standard deviations. Heissell, Adam, Doleac, Figlio, and Meer (2019) shows that low-income students in grades 3–8 experiencing high levels of cortisol during high-stakes standardized exam score 0.4 standard deviations lower than expected. Mani, Mullainathan, Shafir, and Zhao (2013) run a randomized controlled trial and show that inducing thoughts about finances reduces cognitive performance among the low-income individuals.

[4]For example, Winicki and Jemison (2003) reports that the children of parents who report frequently worrying about food running out due to lack of income, or that their children have skipped at least one meal in the last 12 months because money was not available, perform worse on kindergarten assessments. Beharie, Mercado, and McKay (2017) finds that among children who are living in poverty, SNAP participants have lower rates of grade retention.

evidence that school-sponsored lunch programs can mitigate these effects for elementary-aged and middle-school children, there is less evidence on how food availability affects educational attainment for high-school students (Figlio and Winicki, 2005; Schwartz and Rothbart, 2019; Mangrum, 2019).[5]

Two recent studies focus on performance on single-state assessments in young children.[6] Cotti, Gordanier, and Ozturk (2015) exploit variations in SNAP disbursement schedules and exam testing dates in South Carolina and find a negative effect of taking the exam towards the end of the benefit cycle on third through eighth grade standardized math test scores, particularly for African American boys. Gassman-Pines and Bellows (2018) find that for third through eighth graders in North Carolina end-of-grade test scores peak by 0.021–0.022 standard deviations 17–19 days after benefit issuance, which they interpret as a delayed effect of the improved nutrition and reduced household stress induced by the receipt of a SNAP payment. However, we note that these results vary depending based on subgroup.

Our study has several key differences. First, using college attendance data, we measure long-term consequences of the SAT using information on college matriculation rates and college quality, which more closely reflect achievement gaps in adults, as best as these outcomes can be measured by cognitive test scores. This allows us to link short-run nutritional deficiencies in adolescence with determinants of adult earnings through the mechanism of underperformance on the SAT. Second, the aforementioned studies focus on tests that were high-stakes for the schools but not the students. Schools thus had incentives to mitigate factors, nutritional or otherwise, that would hurt student test scores, while the students themselves suffered no potential consequences of the calendar-induced inequality. In particular, these state standardized tests are taken each year on a weekday, when school lunch and breakfast programs may help fill gaps in a student's nutritional intake, and schools may alter caloric offerings to boost scores. In contrast, the SAT is high-stakes for students but not

Laurito and Schwartz (2019) find that SNAP households are more likely to participate in school lunch at the end of the SNAP benefit cycle. Aurino, Fledderjohann, and Vellakkal (2019) find that adolescents in food-insecure households in India score lower on vocabulary, reading, math, and language tests.

[5]Specifically, Figlio and Winicki (2005) finds that increasing calories on school menus on testing days increases math and English pass rates by 11.1 percent and 5.8 percent, respectively. Schwartz and Rothbart (2019) estimates the impact of providing universal free lunch to middle-school students in New York City and finds that school lunch participation increases test scores by 0.08 standard deviations in math and 0.07 standard deviations in reading. Mangrum (2019) analyzes a program that provided low-income elementary students with take-home meals at school on Fridays and finds that treated students scored 0.16–0.28 standard deviations higher on reading and math tests.

[6]Other work provides evidence that the SNAP benefit cycle has important effects on students beyond test scores as well. For example, Gennetian, Seshadri, Hess, Winn, and George (2016) finds that participating students in grades 5–8 are more likely to receive a disciplinary infraction at the end of the benefit month, as compared to non-SNAP students.

for schools, and is generally taken on the weekend, further lessening the ability for schools to reduce nutritional gaps with free or reduced-price breakfast and lunch.

The remainder of the paper is organized as follows. In the next section, we discuss in more detail how SNAP issuance schedules present a natural experiment for studying the effects of food insecurity on adolescent outcomes. We then describe our data and empirical approach and present the results of our analysis on test scores and college outcomes. We conclude by providing evidence against the existence of strategic test-scheduling behavior by students and discuss the costs of nutritional deficiency in lost wages.

2 Background on SNAP Issuance Schedules

SNAP is a means-tested entitlement program administered and funded by the United States Department of Agriculture (USDA). Once per month participating households receive cash-like electronic food vouchers to be spent at authorized SNAP retailers. Although SNAP is federally funded, and the USDA sets minimum allotment standards, state public assistance agencies run the program through their local offices and determine the organization and timing of benefits. As a result, there is significant variation in state SNAP disbursement schedules. While seven states currently distribute all benefits on one day of the month, a majority of states stagger issuance throughout the month, allocating different households benefits on different days of the month.

We focus on students in 8 states that assign benefit dates by last name: Arizona, District of Columbia, Indiana, Iowa, Kansas, Maryland, Utah, and West Virginia.[7] Table A1 provides these schedules of SNAP issuance days throughout the month based on the first letter of the last name, and we will henceforth refer to these separate groups as “letter groups." Since states vary in the assignment of letter groups and receipt day, and SAT test date opportunities are the same for all students, we use this last name-based benefit issuance scheme to isolate as-good-as-random variation in the timing of receipt in our empirical models, which we discuss in further detail below.

[7] Although Connecticut, Hawaii, and Wyoming also stagger benefits by last name, SNAP issuance dates are closely clustered within 2-3 days, which does not provide enough variation to differentiate between potentially “SNAP scarce" or “not SNAP scarce" students for this analysis. Delaware was the only state to change its SNAP schedule timing during this period; we drop Delaware from the analysis (because the schedule is at times ambiguous), but its inclusion does not impact results.

3 Data

To measure how SNAP timing affects academic performance and post-secondary enrollment, we use administrative data on SAT scores, college attendance, and college quality from three main data sets for students in high school cohorts between 2009 and 2014. Data on student characteristics, including race, ethnicity, gender, and grade, as well as high-school characteristics, and SAT scores are from The College Board. The SAT is a college entrance exam, administered by The College Board, intended to test college readiness. Across the US, high-school students voluntarily sit for the 3-hour exam on 1 of 7 offered test dates, typically in their junior or senior year. The SAT consists of math and verbal sections scored on a 200 to 800 point scale, with a highest possible composite score of 1600.[8] The scores are scaled by The College Board depending on test difficulty. In 2014, the average SAT score among college-bound seniors was 1010 (The College Board, 2016).

Students are allowed to retake the SAT as many times as they wish. However, since retakers may vary from other students along important unobservable dimensions (see Goodman, Guarntz, and Smith, 2018), we keep only first-time SAT scores. For similar reasons, we also use only test takers in their junior or senior year of high school.

SNAP is a means-tested program. We cannot directly observe in our data whether any student is a SNAP participant, but can use income measures to classify those who likely would be eligible. First, we know the student's reported household income on the SAT survey. Our preferred approach uses this binned income to judge whether a student is a likely SNAP participant. Although SNAP eligibility limits vary based on state and federal regulations, it is very unlikely that any family earning more than $60,000 per year would be able to participate in the program.[9] Indeed, based on data from the SNAP Quality Control Database, a nationally representative survey of SNAP participants, all SNAP households in our 9 sample states with one or more 16- and/or 17-year olds reported having a household income below $50,000 in 2014, although approximately one percent of respondents reported an income of more than $40,000.[10] This provides us with reason to believe that some students reporting a household income of $40,000–$60,000 are participating in the program.

[8] While the current SAT also includes an essay, this section is optional. Therefore, we omit writing scores for this analysis.

[9] We have similarly considered other income cutoffs, and discuss these results below.

[10] These publicly available data contain information on 48,250 households categorically eligible for SNAP or eligible via applicable income and asset tests, and are accessible here: `https://host76.mathematica-mpr.com/fns/Download.aspx?`.

Because household income data are in bins and are self-reported by students, we additionally use an alternative definition of whether a student is low-income. To do so, we create both school-level and geographic measures to get a better sense of students that are most likely to be affected by SNAP cyclicality. In particular, we classify students as attending a low-income school if 50% of students who report an income select a bin below $60,000.[11] Finally, students report their resident zip code which we merge with Census data from the 2012 American Community Survey to track levels of income and SNAP participation within the area that a student lives. Therefore, we define a student's zip code as low-income if the median income is below $60,000 and define a zip code as high SNAP usage if more than 15% of residents participate in SNAP.[12]

College attendance data are from the National Student Clearinghouse for 2009–2014 cohorts. These data contain information on college going, including enrollment and information on whether the institution is considered a 2-year or 4-year college. Despite the fact that the Clearinghouse tracks all colleges and universities that a student attends, we only consider the first destination, and we do not consider graduation as an outcome due to the fact that the cohorts observed in our data have not had enough time to graduate by then end of our sample period. Importantly, the National Student Clearinghouse tracks students' outcomes at all institutions of higher education, so we retain outcomes for students who attend an out-of-state or private institution, despite only looking at students who take the exam in a limited number of states.

We measure college quality using data from the National Center for Education Statistics Integrated Postsecondary Education Data System (IPEDS). These data include institution-level information on admissions, 12-month enrollment, graduation rates, flagship status, and whether the institution is classified as "selective" according to the Barron's Profiles of American Colleges.[13] We do not observe college quality measures for students who do not attend college, but we do know where every SAT-taker attends college if they do. In our main models we use the same sample

[11] Although the College Board grants waivers to students who receive Free or Reduced Price Lunch (FRPL), whether students receive waivers depends on student and high-school counselor characteristics, introducing room for selection. Also, in one of our largest states, Indiana, school funding depends on the proportion of students receiving FRPL, and we are concerned that this can amplify selection issues.

[12] This SNAP usage cutoff, although seemingly low is around 1 standard deviation above the mean in our sample, and nearly the 90th percentile.

[13] For Barron's selectivity categories, "1" indicates colleges that are "most competitive," "2" is "highly competitive plus," "3" is "highly competitive," and "4 is "very competitive plus." See `https://archive.nytimes.com/www.nytimes.com/interactive/2013/04/04/business/economy/economix-selectivity-table.html` for a list of colleges ranked by their selectivity score.

throughout, controlling for whether a student did not attend college when the outcome of interest is a measure of college quality.

4 Implementing the Natural Experiment

Given that staggered SNAP schedules appear random, our ideal approach would be to estimate a simplistic model using OLS that measures the effect of test scores on the number of days since SNAP receipt. However, based on our summary statistics in Tables 1 and A2, we note that when different “letter groups" receive benefits is correlated with race and ethnicity. This implies that last name letters may be predicted by race and/or ethnicity, and therefore the effects of such benefit schedules are not totally random. Moreover, the day that an individual receives benefits affects their behavior, especially if they receive benefits on a weekend (Castellari, Cotti, Gordanier, and Ozturk, 2017). Finally, if schools are able to predict when individual students get their benefits, they may alter the counseling or nutritional assistance accordingly.

Therefore, in our main analysis, we adopt a fixed effects approach that exploits variation in state-level SNAP benefit schedules and accounts for the recurring timing of benefits, individual characteristics that are correlated with benefit timing, and unobserved school characteristics. We begin by estimating Ordinary Least Squares models of the following form:

$$y_{icst} = \beta_0 + \beta_1 SNAP_{icst} + \pi_c + \psi_d + \gamma_s + \lambda_t + X_{icst} + u_{icst}, \tag{1}$$

where i, c, s, t represent the student, cohort, school, and test, respectively. y represents outcome variables of interest: SAT math score, SAT verbal score, no college attendance, 2-year college attendance, 4-year college attendance, and college quality measures. We use two different measures of SNAP-induced scarcity, represented in the above equation as $SNAP_{icst}$. First, we consider a student i to be “SNAP scarce" if student i sits for SAT exam t 15 days or more after SNAP issuance. This measure is an indicator variable equal to one if a student meets that criteria and zero otherwise. Based on the literature on SNAP families' consumption decisions, 15 days is a reasonable estimate for when families begin to experience SNAP-induced scarcity, as a majority of households exhaust all of their benefits before that point (Castner and Henke, 2011). Alternatively, we measure scarcity more continuously as the number of days since an individual could have been issued SNAP benefits, based on a student's last name. π_c are cohort fixed effects to account for unobserved characteristics across graduation cohorts, λ_t are test fixed effects to control for differences in SAT exam difficulty common to a particular test, and γ_s are school fixed effects to control for any systematic differences across schools. ψ_d represent state-by-day-of-month fixed effects. These are akin to first letter of last name group fixed effects to control for common characteristics of students with the same disbursement date and state, and are especially important to include if last name letter corresponds to race or other factors related to average test scores.

SAT exam dates vary across months and within months across cohorts. Therefore, causal identification in this context relies on comparisons between students within cohort, exam, school, and last name letter group. Our approach implies that, once accounting for the extensive set of fixed effects listed above, there is as-good-as-random variation in students taking the test while food insecure. In Section 5, we discuss this idea further and provide additional tests to support the validity of our identification assumption.

In some specifications, we include X_{icst}, a vector of individual-level controls for race, ethnicity, and gender, and, when available, a set of additional controls from the College Board survey that accompanies the SAT that contains information on mother's education level, and whether the student was ranked in the top 10 percent of their class. Finally, u_{icst} is a random error term that we allow to be correlated across time within a state-by-cohort-by day of disbursement.[14]

As discussed above, it is very unlikely that a student with household income above $60,000 would be able to participate in SNAP. Exploiting the fact that SNAP is a means-tested program, we consider those students who report an income below that threshold to be the potential treatment group in a difference-in-differences style model as our main specification. We focus on this approach for two reasons. First, although effects are still intent-to-treat in this model, this coefficient will be closer to capturing the treatment-on-the-treated than the full sample approach of Equation (1). Second, using higher-income students as a control group helps to address any lingering concerns that our set of fixed effects cannot fully account for endogeneity between scores and taking the exam

[14]While we cluster on state-by-disbursement day-of-month-by-cohort level because that determines for which test a student is considered "SNAP scarce," our estimates are not sensitive to this choice. Clustering by state and state-by-cohort yield similar results, and results can be found in Table A3.

more than 15 days after potential disbursement. We estimate the following:

$$y_{icst} = \beta_0 + \beta_1 SNAP_{icst} * lowincome_{icst} + \beta_2 SNAPscarce_{icst} + \beta_3 lowincome_{icst} + \pi_c + \psi_d + \gamma_s + \lambda_t + X_{icst} + u_{icst}, \qquad (2)$$

where and $lowincome_{icst}$ is an indicator variable equal to one if a student's reported household income is below \$60,000 and all other variables remain unchanged from Equation 1. Our coefficients of interest in Equations (1) and (2) are both β_1. These coefficients identify the effect of nutritional shortfalls off of differences in the change in performance of individuals with the same letter group sitting for the exam at different times between high-income (non-SNAP participant) and low-income (likely SNAP participant) students.

5 Estimating the Effects of Nutritional Shortfalls on Cognitive Performance and Human Capital

5.1 Effects on SAT Scores

Table 1 separately presents summary statistics for students within 15–31 days of potential SNAP receipt (i.e. "SNAP scarce" students), based on last name, and those within 0–14 days of SNAP issuance (i.e. "Not SNAP scarce" students).[15] These statistics show that, on average, SAT math and verbal scores are approximately 4 and 2 points lower for the SNAP scarce students, respectively. Moreover, these students are more likely to attend no college or attend a 2-year college, while students that take the SAT for the first time while not experiencing SNAP scarcity are more likely to attend a 4-year college but less likely to attend a flagship, or more selective college. Although this simple comparison provides some useful descriptive evidence on the relationship between SNAP issuance, SAT scores and college attendance, the empirical analyses below address a wide set of potential confounders, including differences in demographics, economic conditions, and state-wide policies. Some of these confounders are related to a student's first letter of their last name, which is an important source of underlying variation in SNAP scarcity. This relationship is an important factor in our preference for using the difference-in-difference model described in Equation 2, and it

[15] Similarly, we provide summary statistics by a student's reported household income level in Table A2.

means that a balance test is likely to be uninformative as it will not account for the endogeneity related to first letter of last name and other confounders.

In Figure 1 we analyze the effects of SNAP scarcity across household income levels, using an adaptation of Equation (2). We include indicator variables for $20,000 bins in the SAT survey and their interactions with our "treatment" variable indicating SNAP scarcity.[16] We present coefficients and 95% confidence intervals for each of the interactions.

As discussed previously, it is highly unlikely that any student in a household reporting over $60,000 in annual income would be a SNAP participant. In Panels (a) and (b) of Figure 1, we find statistically significant effects for both SAT math and verbal exams in income ranges below this cutoff. Taking the exam in the last two weeks of the benefit cycle reduces SAT math scores by 2–3 points and SAT verbal scores by 2–4 points. The effects on verbal scores are particularly striking; estimates are statistically significant for households earning $0–$60,000 per year, and they are much larger in magnitude with the largest effects for students in the $0-$20,000 income bin.[17]

Overall, these estimates imply that the reach of SNAP issuance policies, in terms of having an impact on student testing performance, is concentrated within the population of students reporting household annual income less than $60,000. Therefore, in subsequent analysis we focus on specifications that compare potentially SNAP scarce students in these lower-income households to potentially SNAP scarce students who report household income over $60,000. Because SNAP can serve students with higher incomes, depending on household size, and because some students may not accurately report their household income, this approach can be viewed as estimating a lower bound of the true treatment effect. We also emphasize that any estimates based on this research design will represent intent-to-treat effects, because SNAP participation for eligible households is less than 100 percent. Thus, our estimates will understate the effects of SNAP on the students

[16]Students can select $10,000 bins for incomes below $80,000, but we aggregate adjacent bins below that threshold into $20,000 bins for consistency. We also believe it is somewhat implausible that students are accurate within $10,000 when reporting their family income.

[17]For SAT math scores, we estimate a statistically significant drop for the $100,000-$120,000 income bin. This evidence is consistent with the idea that some low-income students report household income of $100,000 when they are unsure. Dropping students reporting income between $40,000-$120,000 yields estimates that are statistically significant at the 1% level and indicate a 2.5 point decrease in math scores and a 3.9 point decrease in verbal scores. Omitting only students in the somewhat ambiguously treated $40,000–$60,000 bin, we find a decrease in math and verbal scores of 2.6 and 4.4 points, respectively, again statistically significant on the 1% level. Estimates of Equation 1 on only students reporting income below $60,000 yield a decrease of 1.5 points in math and just under 1 point in verbal, and although these estimates lack precision, the effect on math is statistically significant on the 5% level. Estimates of Equation 1 for only students with household incomes over $120,000 are small and statistically insignificant.

actually served.

In Table 2 we show corresponding effects of SNAP issuance on math and verbal SAT scores. Beginning with the top panel, which reports estimates from Equation (2), in Columns 1 and 4 we control for state-specific letter group (i.e. “state-by-DOM"), cohort, and test fixed effects.[18] We find that when students sit for the SAT in the last two weeks of the benefit cycle, math scores fall by 4.5 points and verbal scores fall by 6.0 points. As expected, low-income students perform worse on the SAT than their higher-income counterparts, while students that are more likely to experience food insecurity score lower on the SAT math exam, on average.

The inclusion of state-by-letter group fixed effects should account for any permanent differences in race or socioeconomic status that are correlated within state with last name. To account for any time variation in these correlations within state, Columns 2 and 5 include controls for race, ethnicity and gender. As shown in Columns 2 and 5, disparities in SAT scores persist across race, ethnicity, and student background, with black students scoring around 140 SAT points lower than white students, while students in the top 10% score about the same magnitude in the other direction. When including these controls, estimates indicate that SNAP scarcity reduces scores by 2.7 SAT math points, and 4.2 SAT verbal points for low-income students.

We present our preferred specification in Columns 3 and 6, which includes school fixed effects. We do so to account for the fact that school interventions, like counselors or other nutritional initiatives, affect SAT performance differentially across students. Importantly, these controls have little impact on our point estimates, suggesting that, all else equal, the effects within schools do not differ from effects across schools. Further, the coefficient for SNAP scarcity (β_2), which measures the impact on high-income students, is not statistically significant, suggesting our controls are doing a good job of capturing confounders for the natural experiment, and mirrors findings from Figure 1.

We find that, for low-income students, taking the SAT at the end of the SNAP benefit cycle leads to a reduction in SAT math scores of 2.3 points, and a reduction in verbal scores of 3.5 points. Overall, these results imply that taking the exam during periods of relative food insecurity reduces scores by approximately 0.058 standard deviations, which suggests that SNAP timing has larger effects on test scores than heat exposure, but smaller effects than retaking the exam (Goodman,

[18]We have also substituted “SAT opportunity" (i.e. whether it's the first, second, or so on test of the 11 most popular exam choice for a cohort) for exact exam fixed effects and zip code fixed effects for school fixed effects. Estimates are similar to those in Tables 2 and 3, and can be found in Table A3.

Hurwitz, Park, and Smith, 2018; Goodman, Guarntz, and Smith, 2018). Furthermore, our effects are in line with other work showing that students in grades 3–8 receiving benefits 26 days prior to a standardized exam score 0.014–0.045 standard deviations lower than expected (Cotti, Gordanier, and Ozturk, 2018).[19]

In the lower panel of Table 2, we estimate Equation (2) using a continuous definition of SNAP scarcity that measures the impact of SNAP scarcity as the days since the last eligible disbursement for a student's letter group. Similar to our discrete measure, we find performance decreases as students reach the end of the benefit month. Specifically, we find that SAT math and verbal scores fall by 0.08 points and 0.13 points, respectively, for each day after initial SNAP disbursement.

There are a number of different ways a 6-point decrease in the average SAT composite score could occur, and not all may be of equal value to students or policymakers.[20] For example, suppose this decrease was driven solely by a large drop in the scores of the highest achievers. While representing a real decrease in cognitive performance, it may have little actual impact on the trajectory of low-income students. High-ability, low-income students rarely apply to the selective schools that require such high scores for entry (Hoxby and Avery, 2013). In contrast, if these losses were driven by a decrease in performance by marginal students who just barely qualified for admission to state flagships, the economic losses could be quite large (Hoekstra, 2009).

We investigate this latter scenario by analyzing changes in the density of scores in Figure 2. Here, we estimate a set of fixed effects models, as specified by Equation 1, considering whether a student scored in a 100-point range on the SAT math and verbal, separately. We focus on low-income students for simplicity. Our findings suggest that the performance losses are indeed concentrated among marginal students. Students at the end of their potential SNAP benefit cycle are more likely to score between 400–500 points on each section, and less likely to score between 500–600 points—well-within the relevant scope for admissions decisions.[21] In the following section, we will look at

[19]In particular, Goodman, Hurwitz, Park, and Smith (2018) document that a one standard deviation in heat exposure (or three days about 90 degrees F) reduces test scores by 0.002 standard deviations, while Goodman, Guarntz, and Smith (2018) find that students retaking the SAT improve their scores by 90 points, on average, or 0.3 standard deviations.

[20]This is because test scores are ordinal measures of achievement. See Bond and Lang (2013).

[21]These cutoffs vary by state. For example, the SAT admissions cutoff for West Virginia University is a composite score of 910, while the recommended score at Indiana University is 1140. Moreover, Goodman, Hurwitz, and Smith (2017) find that many colleges use hidden SAT cutoffs, and that these cutoffs substantially affect a student's college-going behavior. In particular, marginal low-income students that just made the cutoff were 10–14 percentage points more likely to attend a 4-year college.

the effects on these college attendance and quality outcomes directly.

5.2 Effects on College Attendance and Quality

In the above section, we present stark evidence that 2 weeks after SNAP disbursement low-income students perform relatively poorly on the SAT. Given that the SAT is the most prominently used college entrance exam, and many flagship schools have strict SAT admissions and/or financial aid cutoffs, any effects on SAT scores could have large long-run consequences for underperforming students. In this section, we consider to what extent these effects translate into college attendance and quality.

In Table 3, we estimate the effects of SNAP disbursement on college attendance using Equation 2 with a full set of controls (as in Columns 3 and 6 in Table 2). While we find little evidence that taking the exam during a time of scarcity reduces the rate of post-secondary enrollment for low-income students (in Column 3), we do see evidence that it changes the type of colleges students enroll in (Columns 4 and 5). Students taking the exam during a period of potential food scarcity are 0.82 percentage points more likely to attend a 2-year college, and 0.66 percentage points less likely to attend a 4-year college.[22] This corresponds to approximately 1167 fewer students attending a 4-year college as a result of taking the exam during a period of relative resource scarcity over the span of 6 cohorts in our data.[23] Given that many 2-year colleges do not require SAT scores for admission, this result is perhaps unsurprising.

Table 3 Columns 6–9 explore the quality dimension further, by estimating the effect on the overall graduation rate and the average SAT score of the college attended, whether or not the school is classified as "selective" according to Barron's rankings, and if the college is considered a flagship university.[24] We find evidence for a reduction in quality on each of these dimensions. In particular,

[22]For context, our estimates imply an economically meaningful effect, but are smaller than SAT-focused initiatives. In our sample, 68.1 percent of students who are not experiencing scarcity when they take the exam attend a 4-year college, so the 0.7 percentage point decrease is less than a 1 percent decrease. Specifically, Bulman (2015) analyzes how much SAT taking responds to the distance of an available testing center and finds that opening a testing center corresponds to an increase in 4-year enrollment by 4 percent, while offering free in-school administration of the SAT increases enrollment by nearly 8 percent. Goodman, Guarntz, and Smith (2018) estimate that retaking the SAT increases the probability of enrolling in a 4-year college by 20 percent, and Hurwitz, Smith, Niu, and Howell (2015) document that SAT requirements for high-school juniors increases 4-year enrollment by 4-6 percent.

[23]This calculation is based on the fact that our data contain 169,085 students within a household income below $60,000.

[24]For students who do not attend college, we assign 0 for all college quality measures and we add a control to Equation 2 indicating that a student did not attend college. If we instead only consider college quality for students who attend some kind of post-secondary education, we find effects are a slightly larger and remain statistically

students who take the SAT for the first time 3–4 weeks after possible SNAP issuance attend colleges with a 2.79 point lower average SAT score. Moreover, these students are 0.86 percentage points less likely to attend a selective college and are 0.46 percentage points (2.5 percent) less likely to attend a flagship.

These findings are especially important for informing how food insecurity can affect student trajectories. For example, Goodman, Hurwitz, and Smith (2017) show that attending a higher quality institution increases college completion for low-income students by 46 percentage points, which is consistent with other work showing the graduation rate penalty associated with students choosing a 2-year over a 4-year college (Long and Kurlaender, 2009; Reynolds, 2012; Brand, Pfeffer, and Goldrick-Rab, 2014). In Section 6 we further discuss the potential costs to students facing these nutritional gaps.

5.3 Subgroups and Treatment-on-the-Treated Effect

Because we cannot observe whether any student is enrolled in SNAP, all of our estimates so far are intent-to-treat. In this section, we present additional subgroup results for the groups we think are most likely to experience food insecurity. As any of our subgroups approaches 100% SNAP participation, our estimates will approach the treatment-on-the-treated effect for at least that subgroup.

First, in Table 4, we show effects on college attendance and college quality outcomes by neighborhood type. In the first panel, we use a school-level measure indicating that at least half of students in a school who report an income in the SAT survey report one that is below $60,000. In the second panel, we measure low-income status using SNAP usage in the student's zip code, considering all students whose zip codes have at least 15% SNAP participation. Last, we focus on zip codes where the median income is less than $60,000.[25]

Table 4 Column 1 reports SAT math scores, and Column 2 reports SAT verbal scores. Overall, estimates are statistically similar to our main results, but substantially larger. We find that sitting for the exam at the end of the SNAP benefit cycle leads to a decrease in math and verbal SAT scores of approximately 10 points for students in low-income schools for a combined effect of 20 points, or 0.2 standard deviations. Students living in zip codes with relatively high levels of SNAP

significant.

[25] Given that school attended and zip code are both determined or defined geographically, we do not include school fixed effects, noting that including school fixed effects has little impact on our baseline estimates, reported in Table 2.

participation experience a decrease of about 10 points in math and 9.7 points in verbal, for an overall impact of around 20 points. Lastly, effects for students living in low-income zip codes are very close to our main results, which is unsurprising given that our main results are driven by students living in low-income households.

In Columns 3–5, we show estimates for college attendance outcomes. Across panels, we find that students in low-income schools, high SNAP usage zip codes, and low-income zip codes are between 2.2–3.5 percentage points less likely to go to any college, and 2.0–3.6 percentage points less likely to attend a 4-year college. Estimates for 2-year colleges are statistically insignificant and relatively imprecise.

Finally, in the last four columns, we show effects of SNAP cyclicality on college selectivity outcomes. In general, we find that students in low-income communities taking the exam when "SNAP scarce" attend less selective colleges with lower average graduation rates. Specifically, students in low-income high schools are 1.8 percentage points less likely to attend a selective college, and attend a college with a 3.9 point lower average SAT score. When analyzing high SNAP and low-income zip codes, these effects are similar; estimates indicate that for those low-income, "SNAP scarce" students attending college choose a school that has a 1.7–3.4 lower average SAT score and are 1.3–1.7 percentage points less likely to choose a selective college.

Furthermore, we take advantage of the continuous nature of the SNAP participation variable by interacting it with $SNAPscarce_{icst}$, and we show these results in Table 5. Estimates for SAT scores indicate that students living in zip codes with 100% household SNAP participation score 37 points lower on math and 36 points lower on verbal when they take the SAT 15 days or more after their SNAP benefit receipt date. When we consider SNAP participation for those under 18, those effects nearly double to 66 points and 63 points, respectively. This implies that students in communities with high SNAP participation score up to between 70 and 130 points lower on the SAT when they experience food scarcity. In a zip code where 100% of children receive SNAP benefits, any student we observe must be a SNAP recipient - that means low-income students taking the SAT at the end of their SNAP benefit cycle experience a loss of up to 95 points on the exam. That said, there are very few places where SNAP usage is so high, and none in our sample, so we are extrapolating out of sample. Moreover, this large estimate may not represent a average effect because it is possible that the effects are amplified in neighborhoods with high SNAP usage. While we recognize these realities, we submit that the results in Table 5 are a plausible upper bound of the treatment on the treated.

Median income is another continuous variable that describes a student's local socioeconomic conditions. In Column 3 of Table 5 we report the interaction of the binary indicator for scarcity and median income in the student's zip code (in $1000s). As this measure increases, students are becoming less low income, so the direction of effects should be the opposite of the other measures in the table. A student living in a zip code with an additional $10,000 of median income will score around one point lower on each section of the exam when experiencing scarcity. These estimates are very consistent with the main models in Table 2.

Finally, to get a better sense of the treatment variation across student subgroups, in Table 6, we explore how effects differ across minority status and gender. Specifically, in the top panel we provide estimates from analogues of Equation 1, interacting our main treatment variable ($SNAP\,scarce_{icst}$) with a dummy variable for under-represented minority status (whether a student reported being black, Hispanic or Native American) in the top panel, and with an indicator variable for female in the bottom panel.

We choose to combine underrepresented minorities into one group rather than looking at them separately because each group is drawn from primarily one or two states in our sample. In an effort to obtain nationally-applicable estimates and avoid making claims about a particular group based on one state's eccentricities, we combine them here. Only students who reported an answer to the race/ethnicity survey question are included in this analysis and those who selected "other" are also omitted. This means that the non-URM students in the sample reported being white or Asian.

Overall, estimates for underrepresented minorities are larger than our main results, with reductions in SAT scores around 13 points. For college attendance and quality outcomes, underrepresented minorities are not impacted any more than the general student population by SNAP scarcity. They may even be impacted less for some outcomes, namely "Start 2-Year" and "Selective". Because underrepresented minorities are less likely to attend high-quality institutions at baseline, this may reflect the fact that the possible magnitude of a reduction is limited. Underrepresented minorities are more likely to not attend college as a result of scarcity, but this result is just outside of conventional levels of statistical significance (p = 0.117).

When separating effects by gender, as shown in the bottom panel of Table 6, our main findings on SAT scores seem to be affecting both male and female students; however, female SNAP-scarce students experience more substantial college quality effects. Specifically, female students are 1.6 percentage points less likely to attend a 4-year college and 1.6 percentage points more likely to attend a 2-year college. This could reinforce the notion that females are more discouraged by lower scores than males, consistent with psychological theories of stereotype vulnerability (Ost, 2010).

5.4 Effects on Test-Taking

If students are forward-looking, they may make decisions about whether to sign-up for an exam or show up for an exam for which they are registered based on whether they are experiencing SNAP-induced scarcity on the test date. Based on the strength of norms about which tests students take, and the fact that registration deadlines are a month before the exam, we think that the latter phenomenon is more likely; specifically, students may not show up to take the test when they are experiencing SNAP scarcity. Importantly, we do not observe these "no shows" directly, because no record is created for an SAT test if no score is created. Therefore, to investigate the extent to which SNAP benefit timing affects student selection into test taking, we instead use the population of PSAT-takers to determine whether students are less likely to take the SAT (ever) when the test schedule is such that they are likely experiencing scarcity during the most popular tests.[26]

For each PSAT-taker, we create a measure of likely scarcity using the dates of SAT exams during that student's junior and senior year and their SNAP disbursement date. We determine whether the student would have been classified as "SNAP scarce" during the 4 most common exams: May and June of junior year and October and November of senior year. We then estimate a model using the proportion of those exams during which the student would have been classified as experiencing SNAP-induced scarcity as our independent variable, like substituting this proportion for $SNAPscarce_{icst}$ in Equation 1. Our outcome of interest is whether students ever take an SAT test. For reference, 9.4% of students have scarcity for zero exams, 16% have scarcity for 1 exam, 10% have scarcity for 2 exams, 20% have scarcity for 3 exams, and the remaining 45% have scarcity for all of the most common exams. These proportions are the same for students at low-income

[26]The PSAT is an exam given only once per year primarily to freshmen-juniors in high school. While often cited as a practice for the SAT, as it is very similar in format, it also plays a primary role in the National Merit Scholars program. Eligibility for this nationwide scholarship program is determined by scores in the junior year of high school, and most college-bound students take it.

schools. We take the fact that so many students face scarcity during all of the major exams as further evidence that students are unlikely to intentionally schedule exam-taking during an exam when they do not experience scarcity.

We include controls for race and gender, but all controls from the SAT survey cannot be included because we are including students who never took it. We include the full set of fixed effects as in Columns 3 and 6 in Table 2. Importantly, we also cannot use a student's reported family income because it will only exist for students who take the SAT, so we instead rely on our measure of school-level socioeconomic status and our two zip code measures as defined in the previous section to focus on the students most likely impacted.

Table 7 contains the results of this analysis. Because the measure of scarcity ranges from zero to one, the coefficient captures the effect of a student experiencing scarcity for all 4 exams relative to experiencing scarcity for none of them. Estimates indicate that there is no perceptible effect on test-taking behavior. In Column 2 we analyze effects for students who attend low-income schools (again measured by the percentage of low-income students). Estimates are statistically insignificant are close to zero, suggesting no meaningful effects on test-taking behavior. Similarly, there are no differential effects related to zip code level poverty measures.[27]

6 Assessing Costs to Students

In this section, we aim to quantify the costs associated with performance losses for students who take the SAT while experiencing scarcity. First, we consider the tradeoffs in wages for attending a 4-year versus a 2-year college. Carnevale, Rose, and Cheah (2011) estimate that an average college graduate will earn $2.8 million over his/her lifetime. Reynolds (2012) estimates that wage penalties for starting at a 2-year college are approximately 3.0 percent for women and 2.3 percent for men, even if a student later matriculates to a 4-year college. Therefore, these estimates suggest that the lifetime penalty of the marginal student attending a 2-year college instead of a 4-year college is

[27] We can also use the PSAT data to estimate whether "SNAP scarce" students perform worse on this exam as well. Overall, effects are similar in magnitude to our main results, indicating a 0.29 point and 0.22 point decrease in PSAT-Math and PSAT-Verbal scores, respectively, for students in low-income schools, which correspond to reductions of 2.9 and 2.2 SAT points. Estimates remain consistent if we focus only on students taking the PSAT in their junior year only. Overall, these estimates are less precise than the main results, potentially due to the fact that we do not have information on household income for PSAT-takers, and do not have a rich set of controls for theses students.

$84,000 for women and $64,400 for men.[28] If the 0.69% decrease that we find in 4-year college-going for low-income students is completely transferred to 2-year college attendance (as Table 3 suggests), then the foregone wages are around $86.6 million for the 1167 students who do not attend a 4-year college.

If we instead focus on students who chose to forego college altogether, this wage gap is even higher. For example, the earnings of bachelor's graduates from households with earnings of less than 1.85 times the federal poverty level are 71 percent higher than those of high school graduates, or $812,250, on average (Bartik and Hershbein, 2018).[29] If the 0.66 percent decrease that we find in 4-year college-going for low-income students results in those 1167 students not attending college (as the geographic subgroups would suggest), the lost earnings are $948 million.[30]

Next, we can consider the foregone benefits of a student who chooses to attend a 4-year college attending a less selective college. Dale and Krueger (2002) estimate up to a 7 percent wage premium for those attending a college whose students score 100 points higher on the SAT. Following the procedure in Pallais (2015), we use this estimate specifically since Dale and Krueger (2002) analyze a subset of low-income students. Because the students eligible for SNAP are low-income, these estimates will yield an estimate closer to the treatment on the treated. Using these estimates, the average lifetime wage cost of a low-income student scoring 6 points lower on the SAT and attending a less selective 4-year college is $2,800,000 x 7% x 0.06= $11,760. For our alternative measure of low-income students based on geography, estimates imply an even larger cost of $2,800,000 x 7% x 0.17= $33,320 (based on a 17-point reduction in SAT scores reported in Table 4).

Moreover, these estimates will understate the costs of SNAP cyclicality to low-income students if graduation is more likely at these higher quality colleges. Indeed, Hoekstra (2009) finds that attending a flagship state university increases earnings by 20 percent. Similarly, Goodman, Hurwitz, and Smith (2017) find that inducing low-income students to attend a 4-year college instead of a 2-year college increases completion by 22 percentage points, suggesting that institutional peer effects

[28] The calculations for men's and women's earnings respectively are $2,800,000 x 3% and $2,800,000 x 2.3%. Estimates are calculated in 2008 dollars.

[29] This is based on discounted lifetime earnings of $475,000 for low-income students who obtain only a high school diploma (Bartik and Hershbein, 2018).

[30] Considering estimates from Bartik and Hershbein (2018) are not plausibly causal, this estimate is likely an upper bound. According to Zimmerman (2014), students just missing the cutoff for a 4-year state university yield total earnings losses of $12,000 7 years after high-school graduation, although these gaps are expected to grow as workers age.

play an important role in longer-run outcomes. Given that Card (1995) estimates that low-income students' earnings increase by up to 14 percent for each additional year of college, the potential lifetime benefit of graduating a 4-year school for these marginal students is therefore $1,727,000 x 28% = $483,560.

We recognize that for a student whose alternative is going straight into the workforce, the opportunity costs of attending college is lost wages at an entry-level job. We also acknowledge that there are additional costs and burdens a student must consider when deciding to attend a 4-year college over a 2-year college or no college at all. These upfront costs include time to complete the application to a 4-year school, the time of the admissions officer evaluating the application, tuition and fees, and potential moving and transitional/psychic costs that a student would otherwise not incur if they lived at home. These costs of attending college are salient for students, but unlikely to outweigh the benefits accrued to students of attending a 4-year college detailed above.

7 Discussion

In this paper we use variation in state SNAP schedules to analyze how nutritional assistance timing can affect high-stakes exam scores and college attendance. We find that when SAT dates fall more than two weeks after a student's SNAP benefit issuance date, math and verbal scores are 2.3 and 3.5 points lower, respectively, for low-income students. This translates into lower 4-year college attendance, and we provide some evidence of substitution to 2-year colleges. Notably, we also find large, robust effects indicating that students attend lower quality institutions measured by selectivity rankings and average SATs of admitted students. Effects are largest for students attending low-income schools and living in zip codes with high levels of SNAP participation, and are not driven by changes in test-taking behavior.

Most importantly, these findings are critical for understanding the hurdles to college going that children in poverty face. Our results suggest that students perform worse during the parts of the month during which they encounter relative scarcity, echoing findings that many families experience food insecurity at the end of the month (Castner and Henke, 2011). Taken together, our findings suggest that the documented socioeconomic gap in nutritional intake results in lifelong gaps in human capital formation, and the potential benefits of alleviating resource scarcity at the end of the benefit month could far outweigh administrative transition costs. Considering the evidence that lower SAT scores result in students attending lower-quality colleges, leading to lower lifetime wages, our findings provide evidence that achievement gaps for low-income students may be related to the timing of nutritional assistance (Hoekstra, 2009). We also show that students living in low-income communities perform even worse on the SAT when experiencing scarcity.

Finally, we note that there are a number of policy implications that could address the obstacles that low-income children face and ensure that food cyclicality does not stunt the earnings trajectory for these students. Considering that food insecurity can affect not only the SAT, but standardized exams throughout a child's schooling career, policymakers should consider the spillover benefits of optimal SNAP timing and/or expanding the scope of school meals. For example, offering the SAT and other high-stakes exams on school days would potentially increase participation and allow students eligible for free school breakfast and lunch to eat prior to the test. Indeed, many school districts have been moving in this direction; as of 2019, 43 percent of SAT takers took the exam on a school day, up from 36 percent the previous year (The College Board, 2019).

Moreover, expanding SNAP participation or monthly benefit amounts could in and of itself improve gaps in nutritional availability and, subsequently, child health and achievement (East, 2018). Alternatively, deliberately staggering the electronic delivery of multiple types of transfers over the course of the month would be relatively low cost, but would benefit families and communities more broadly.[31] Careful scheduling of other transfers families receive in conjunction with SNAP (such as wages from work or TANF) could also help to alleviate consumption shocks, as could splitting households' monthly benefits into multiple payments. Overall, these findings imply that once-per-month benefit timing has large educational consequences for adolescents. Given that the cyclicality of SNAP benefits has been shown to affect crime (Carr and Packham, 2019a,b), alcohol purchases (Castellari, Cotti, Gordanier, and Ozturk, 2017), drunk driving (Cotti, Gordanier, and Ozturk, 2015), and substance use events (Allen, Atwood, Young, Pauly, and Harrington, 2019) our estimates contribute to a broader literature on how the timing of other government transfers can affect total social welfare. In focusing on the timing of public health interventions, policymakers could more directly address the consequences of food insecurity and poverty more generally.

[31]For example, one state in 2014 estimated that delivering benefits to recipients on different days of the month would cost approximately $294,010, of which only $76,500 was due to internal systems staff programming time, while the remainder represents one-time notification costs (House Joint Resolution 43, 2013).

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Table 1: Summary Statistics

	Not SNAP Scarce < 15 days since SNAP		SNAP Scarce ≥ 15 days since SNAP	
	Mean	St.Dev.	Mean	St.Dev.
Student Characteristics				
SAT Math	501.923	(103.967)	498.276	(106.358)
SAT Verbal	495.413	(101.627)	494.210	(103.621)
Black	0.116	(0.320)	0.169	(0.375)
Hispanic	0.092	(0.288)	0.088	(0.284)
Asian	0.044	(0.204)	0.056	(0.230)
Male	0.467	(0.499)	0.473	(0.499)
Observations	169,923		258,017	
College Outcomes				
No College	0.127	(0.333)	0.132	(0.338)
Attend 2-Yr College	0.192	(0.394)	0.223	(0.416)
Attend 4-Yr College	0.681	(0.466)	0.645	(0.478)
Observations	169,923		258,017	
College Characteristics				
Barrons Top 4	0.759	(0.427)	0.814	(0.389)
Flagship	0.203	(0.403)	0.206	(0.405)
College 6 Year Graduation Rate	56.900	(18.325)	58.678	(18.068)
College Avgerage SAT	1086.786	(118.764)	1093.834	(125.977)
Observations	109,192		156,148	

Notes: Data span 2009–2014 cohorts and include the following states: Arizona, District of Columbia, Indiana, Iowa, Kansas, Maryland, Utah, and West Virginia. Data on SAT scores are from The College Board. Data on college attendance are from the National Student Clearinghouse. Data on college characteristics are from IPEDS and are only reported for students who attend college. Students within 15–31 days of potential SNAP receipt, based on state-level SNAP issuance schedules and student last name are the students who may be experiencing scarcity. Students within 0–14 days of potential SNAP receipt are less likely to be experiencing SNAP-related scarcity.

Table 2: The Effect of SNAP Timing on SAT Scores

	SAT Math			SAT Verbal		
Scarcity Indicator						
$\geq$ 15 days since SNAP * Income $<$ 60k	-4.5458***	-2.6736***	-2.2656***	-6.0468***	-4.1595***	-3.4554***
	(0.9895)	(0.8081)	(0.6444)	(1.1043)	(0.9004)	(0.6992)
$\geq$ 15 days since SNAP	-1.8374**	-1.3783**	-0.8199	-0.4469	-0.0752	0.2968
	(0.8291)	(0.6913)	(0.5993)	(0.7660)	(0.6640)	(0.5748)
Income $<$ 60k	-32.9072***	-21.1614***	-13.2667***	-31.1484***	-21.7079***	-13.3309***
	(0.8315)	(0.6633)	(0.5313)	(0.9995)	(0.7799)	(0.6140)
Black		-75.5467***	-62.5294***		-66.2783***	-56.5209***
		(0.9016)	(0.5710)		(0.7466)	(0.5923)
Hispanic		-30.4969***	-29.2080***		-31.4561***	-30.0089***
		(0.6888)	(0.6020)		(0.7843)	(0.6118)
Asian		40.2735***	27.8692***		-5.5515***	-15.2969***
		(1.8059)	(1.3408)		(1.2762)	(0.9515)
Native		-27.9910***	-23.0413***		-28.9195***	-22.6588***
		(1.7854)	(1.7378)		(2.0746)	(1.9439)
Male		33.3916***	32.7912***		4.7386***	4.1741***
		(0.4085)	(0.3970)		(0.4687)	(0.4513)
Days Since SNAP						
Days since SNAP * Income $<$ 60k	-0.1458***	-0.0839**	-0.0802***	-0.2019***	-0.1420***	-0.1258***
	(0.0431)	(0.0362)	(0.0296)	(0.0482)	(0.0397)	(0.0315)
Days since SNAP	-0.0534*	-0.0373	-0.0098	-0.0028	0.0131	0.0360
	(0.0298)	(0.0266)	(0.0231)	(0.0285)	(0.0256)	(0.0223)
Income $<$ 60k	-33.2520***	-21.3903***	-13.3104***	-31.4751***	-21.8765***	-13.3403***
	(0.9508)	(0.7645)	(0.6175)	(1.1187)	(0.8742)	(0.6902)
Black		-75.5839***	-62.5425***		-66.3243***	-56.5388***
		(0.9028)	(0.5714)		(0.7469)	(0.5929)
Hispanic		-30.5032***	-29.2126***		-31.4622***	-30.0148***
		(0.6874)	(0.6018)		(0.7831)	(0.6116)
Asian		40.2584***	27.8592***		-5.5765***	-15.3153***
		(1.8063)	(1.3408)		(1.2754)	(0.9513)
Native		-27.9857***	-23.0411***		-28.9177***	-22.6631***
		(1.7841)	(1.7372)		(2.0723)	(1.9429)
Male		33.3902***	32.7885***		4.7375***	4.1713***
		(0.4085)	(0.3971)		(0.4688)	(0.4515)
Observations	427,940	427,940	427,940	427,940	427,940	427,940
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Test Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	No	No	Yes
School Fixed Effects	No	Yes	Yes	No	Yes	Yes

Notes: Estimates are based on data from The College Board on SAT scores from 2009–2014 cohorts. Controls include indicator variables for race, ethnicity, and gender, mother's education level, and whether the student was ranked in the top 10 percent of their class. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.
*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 3: The Effect of SNAP Timing on SAT and College Outcomes

	SAT-Math	SAT-Verbal	No College	Start 2 Yr	Start 4 Yr	Grad Rate	Avg SAT	Selective	Flagship
Scarcity Indicator									
$\geq$ 15 days since SNAP * Income $<$ 60k	-2.2656***	-3.4554***	-0.0016	0.0082***	-0.0066**	-0.3469***	-2.7938***	-0.0086**	-0.0046**
	(0.6444)	(0.6992)	(0.0025)	(0.0030)	(0.0033)	(0.1151)	(0.7047)	(0.0035)	(0.0022)
Days Since SNAP									
Days since SNAP * Income $<$ 60k	-0.0802***	-0.1258***	-0.0001	0.0003**	-0.0002	-0.0091*	-0.0739**	-0.0003*	-0.0001
	(0.0296)	(0.0315)	(0.0001)	(0.0001)	(0.0001)	(0.0052)	(0.0307)	(0.0002)	(0.0001)
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Estimates are based on data from The College Board on SAT scores and National Student Clearinghouse data on college attendance from 2009–2014 cohorts. Controls include indicator variables for race, ethnicity, and gender. We also include a binary indicator for whether a student attended college in columns 6-9. Graduation rate and average SAT scores are missing for some students who do attend college, and we include a binary indicator for that case in models for those outcomes. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 4: The Effect of SNAP Timing in Low-Income Communities

	SAT-Math	SAT-Verbal	No College	Start 2-Year	Start 4-Year	Grad. Rate	Avg SAT	Selective	Flagship
Low-Income Schools									
$\geq$ 15 days since SNAP * Low income school	-9.9968***	-9.7718***	0.0355***	0.0004	-0.0359***	-0.5694***	-3.8522***	-0.0179***	-0.0033
	(1.6198)	(1.6134)	(0.0052)	(0.0036)	(0.0059)	(0.1740)	(1.1939)	(0.0042)	(0.0023)
Observations	720,765	720,765	720,765	720,765	720,765	720,765	720,765	720,765	720,765
High SNAP Usage Zip Codes									
$\geq$ 15 days since SNAP * High SNAP zipcode	-7.1186***	-6.7189***	0.0251***	-0.0027	-0.0223***	-0.7019***	-3.3830***	-0.0172***	-0.0043*
	(1.1679)	(1.2094)	(0.0035)	(0.0031)	(0.0044)	(0.1490)	(1.0283)	(0.0035)	(0.0022)
Observations	726,690	726,690	726,690	726,690	726,690	726,690	726,690	726,690	726,690
Low-Income Zip Codes									
$\geq$ 15 days since SNAP * Low income zip	-5.3987***	-5.3972***	0.0226***	-0.0030	-0.0196***	-0.4260***	-1.6506*	-0.0128***	-0.0014
	(1.1761)	(1.2130)	(0.0036)	(0.0034)	(0.0046)	(0.1381)	(0.9328)	(0.0038)	(0.0023)
Observations	726,690	726,690	726,690	726,690	726,690	726,690	726,690	726,690	726,690
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	No	No	No	No	No	No	No	No	No

Notes: Estimates are based on data from The College Board on SAT scores and National Student Clearinghouse data on college attendance from 2009–2014 cohorts. Zip code-level data on SNAP participation are from the 2012 American Community Survey. Controls include indicator variables for race, ethnicity, and gender. We also include a binary indicator for whether a student attended college in columns 6-9. Graduation rate and average SAT scores are missing for some students who do attend college, and we include a binary indicator for that case in models for those outcomes. "Low-Income Schools" includes schools with a majority of students reporting a household income lower than $60,000. "High SNAP Usage Zip Codes" includes zip codes with over 15 percent of households participating in SNAP. "Low-Income Zip Codes" include zip codes with median income below $60,000. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 5: The Effect of SNAP Timing on SAT Scores and College Attendance, by Zip Code SNAP Participation

	% Total Pop. SNAP	% Children SNAP	Median Family Income (in 1000s)
SAT-Math			
$\geq$ 15 days since SNAP * Zip Charactersistic	-37.4771***	-66.3445***	0.1044***
	(3.0033)	(5.0113)	(0.0085)
SAT-Verbal			
$\geq$ 15 days since SNAP * Zip Charactersistic	-35.7684***	-63.2896***	0.0889***
	(2.8233)	(4.5660)	(0.0075)
No College			
$\geq$ 15 days since SNAP * Zip Charactersistic	0.0721***	0.1142***	-0.0001***
	(0.0107)	(0.0164)	(0.0000)
Start 2-Year			
$\geq$ 15 days since SNAP * Zip Charactersistic	0.0524***	0.0987***	-0.0002***
	(0.0135)	(0.0219)	(0.0000)
Start 4-Year			
$\geq$ 15 days since SNAP * Zip Charactersistic	-0.1245***	-0.2129***	0.0003***
	(0.0150)	(0.0244)	(0.0000)
College Graduation Rate			
$\geq$ 15 days since SNAP * Zip Charactersistic	-4.5998***	-7.8601***	0.0155***
	(0.4091)	(0.6644)	(0.0013)
College Average SAT			
$\geq$ 15 days since SNAP * Zip Charactersistic	-25.7813***	-43.2224***	0.1064***
	(2.9351)	(4.5373)	(0.0104)
Selective			
$\geq$ 15 days since SNAP * Zip Charactersistic	-0.1593***	-0.2749***	0.0004***
	(0.0130)	(0.0214)	(0.0000)
Flagship			
$\geq$ 15 days since SNAP * Zip Charactersistic	-0.0542***	-0.0947***	0.0001***
	(0.0089)	(0.0144)	(0.0000)
Observations	724,653	724,653	724,370
Basic Controls	Yes	Yes	Yes
Survey Controls	Yes	Yes	Yes
State-by-DOM Fixed Effects	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes
Test Fixed Effects	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes

Notes: Estimates are based on data from The College Board on SAT scores and National Student Clearinghouse data on college attendance from 2009–2014 cohorts. Controls include indicator variables for race, ethnicity, and gender. We include an additional control equal to one for students who did not attend a 2- or 4-year college in regressions with dependent variables related to college quality. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.

Table 6: Demographic Subgroups

	SAT-Math	SAT-Verbal	No College	Start 2-Year	Start 4-Year	Grad. Rate	Avg SAT	Selective	Flagship
Interacting Race with Treatment									
$\geq$ 15 days since SNAP * Income $<$ 60k	0.3579	-1.1755	-0.0035	0.0122***	-0.0087**	-0.2900**	-1.6398**	-0.0132***	-0.0060**
	(0.6816)	(0.8218)	(0.0026)	(0.0035)	(0.0036)	(0.1231)	(0.7083)	(0.0038)	(0.0023)
* URM	-5.9063***	-6.4938***	0.0044	-0.0089**	0.0045	-0.0386	-1.9197**	0.0110***	0.0044*
	(0.8997)	(0.8700)	(0.0032)	(0.0045)	(0.0043)	(0.1252)	(0.8935)	(0.0041)	(0.0024)
Observations	414,055	414,055	414,055	414,055	414,055	414,055	414,055	414,055	414,055
Interacting Gender with Treatment									
$\geq$ 15 days since SNAP * Income $<$ 60k	-2.8885***	-3.3045***	-0.0018	-0.0008	0.0027	-0.1289	-2.1650***	0.0016	-0.0043*
	(0.8301)	(0.9353)	(0.0028)	(0.0036)	(0.0039)	(0.1345)	(0.8014)	(0.0040)	(0.0025)
* Female	0.7583	-1.2246*	0.0004	0.0155***	-0.0160***	-0.3733***	-0.8792	-0.0176***	0.0003
	(0.6957)	(0.7162)	(0.0025)	(0.0032)	(0.0036)	(0.1171)	(0.6879)	(0.0034)	(0.0022)
Observations	427,940	427,940	427,940	427,940	427,940	427,940	427,940	427,940	427,940
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Estimates are based on data from The College Board on SAT scores and National Student Clearinghouse data on college attendance from 2009–2014 cohorts. Controls include indicator variables for race, ethnicity, and gender. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.
*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 7: The Effect of SNAP Timing on SAT-Taking and College Outcomes

	All Students	Low-Income School	High SNAP Zip	Low-Income Zip
Ever Took SAT				
SNAP Scarce % Main 4 Exams	-0.0334	-0.0607	-0.0341	-0.0355
	(0.0218)	(0.0387)	(0.0255)	(0.0258)
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes
Basic Controls	Yes	Yes	Yes	Yes
Survey Controls	No	No	No	No
School Fixed Effects	Yes	Yes	Yes	Yes

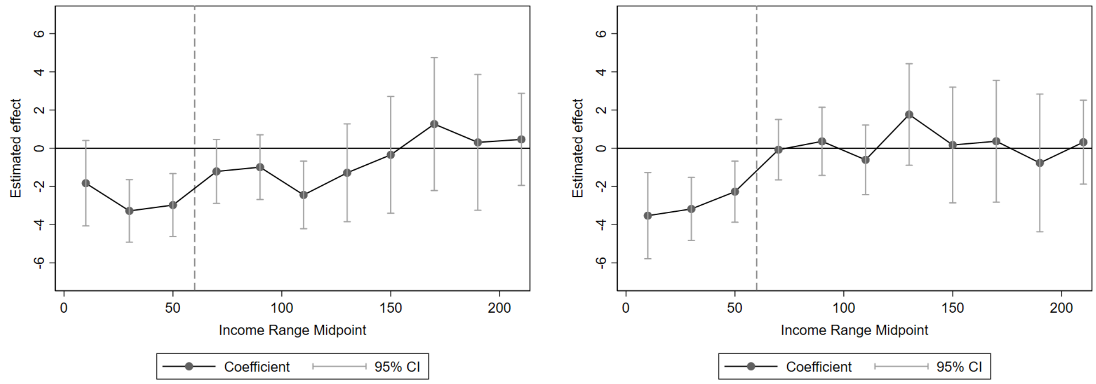
Notes: Estimates are based on data from The College Board on PSAT and SAT scores and National Student Clearinghouse data on college attendance from 2009–2014 cohorts. Zip code-level data on SNAP participation are from the 2012 American Community Survey. The sample includes only students that took the PSAT. Basic controls include indicator variables for race, ethnicity, and gender. Survey controls are only available for SAT takers, and include mother's education level, and whether the student was ranked in the top 10 percent of their class. "Low-Income Schools" includes schools with a majority of students reporting a household income lower than $60,000. "High SNAP Usage Zip Codes" includes zip codes with over 15 percent of households participating in SNAP. "Low-Income Zip Codes" include zip codes with median incomes below $60,000. Standard errors are clustered on the state-by-disbursement day-of-month-by-cohort level.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Figure 1: The Effects of SNAP Timing on SAT Scores by Family Income

(a) SAT Math

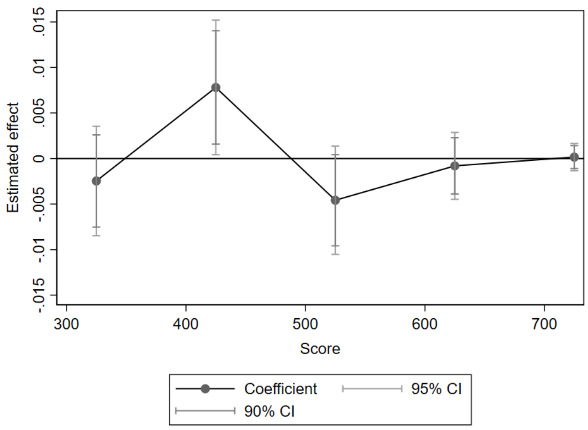
(b) SAT Verbal



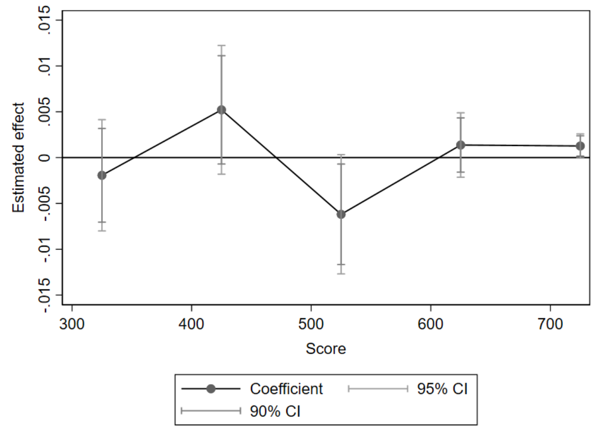
Notes: Data on SAT scores and family incomes are from The College Board. The vertical line, drawn at \$60,000, denotes an approximate household income cutoff for SNAP eligibility. Coefficients and their respective 95% confidence intervals are generated from a regression estimated using OLS, as specified in Equation 2, for \$20,000 household income bins. The main variable of interest is whether a student is "SNAP scarce," i.e. within 15–31 days of potential SNAP receipt, based on their last name. Standard errors are clustered at the state-by-disbursement day-of-month-by-cohort level.

Figure 2: The Effects of SNAP Timing on SAT Score Ranges for Low-Income Students

(a) SAT Math



(b) SAT Verbal



Notes: Data on SAT scores are from The College Board. Coefficients and their respective 95% confidence intervals are generated from 5 separate regressions estimated using OLS, as specified in Equation 1, using an indicator that a student's score falls within a 100 point range as the outcome variable. The main variable of interest is whether a student is "SNAP scarce," i.e. within 15–31 days of potential SNAP receipt, based on their last name.

Appendix

For Online Publication

Table A1: State Issuance Schedules, by State

State	Letter Groups	Issuance Days
Arizona	A-B, C-D, E-F, G-H, I-J, K-L, M-N, O-P, Q-R, S-T, U-V, W-X, Y-Z	1-13
DC	A-B, C, D-F, G-H, I-K, L-M, N-Q, R-S, T-V, W-Z	1-10
Indiana	A-B, C-D, E-G, H-I, J-L, M-N, O-R, S, T-V, W-Z	1-10
Iowa	A-B, C-D, E-G, H-I, J-L, M-O, P-R, S, T-V, W-Z	1-10
Kansas	A-B, C-D, E-G, H-J, K-L, M, N-R, S, T-V, W-Z	1-10
Maryland	A-B, C-D, E-G, H-I, J-L, M-O, P-R, S, T-V, W-Z	6-15
Utah	A-G, H-O, P-Z	5, 11, 15
West Virginia	B & X-Z, C & F, H & N & V, I & M & O & U, Q & S & A & W, J-K & P, D-E & R, G & L & T	1-9

Notes: Data on SNAP issuance schedules is from the USDA.

Table A2: Summary Statistics By Income Level

	Not Low Income > \$60,000		Low Income ≤ \$60,000	
	Mean	St.Dev.	Mean	St.Dev.
Student Characteristics				
SAT Math	520.458	(102.763)	466.170	(100.958)
SAT Verbal	513.653	(100.226)	463.995	(99.543)
Black	0.101	(0.301)	0.225	(0.417)
Hispanic	0.026	(0.158)	0.062	(0.241)
Asian	0.048	(0.213)	0.057	(0.232)
Male	0.498	(0.500)	0.426	(0.495)
Observations	264,500		163,440	
College Outcomes				
No College	0.099	(0.299)	0.179	(0.383)
Attend 2-Year College	0.184	(0.387)	0.255	(0.436)
Attend 4-Year College	0.717	(0.450)	0.566	(0.496)
Observations	264,500		163,440	
College Characteristics				
Barrons Top 4	0.832	(0.374)	0.708	(0.455)
Flagship	0.222	(0.415)	0.170	(0.376)
College 6 Year Graduation Rate	60.478	(17.651)	52.650	(18.176)
College Average SAT	1107.802	(123.136)	1055.644	(115.330)
Observations	179,522		85,818	

Notes: Data on SAT scores are from The College Board. Data on college attendance is from the National Student Clearinghouse. Data on college characteristics is from IPEDS. Students are considered low-income if they report that their family income is below $60,000 on the SAT survey.

Table A3: Alternative Specifications: The Effect of SNAP Timing on SAT Scores and College Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SAT-Math							
$\geq$ 15 days since SNAP * Income $<$ 60k	-2.266***	-2.497***	-2.064***	-2.393***	-1.841***	-2.266***	-2.266**
	(0.644)	(0.709)	(0.651)	(0.711)	(0.632)	(0.800)	(0.828)
SAT-Verbal							
$\geq$ 15 days since SNAP * Income $<$ 60k	-3.455***	-4.076***	-3.109***	-3.807***	-3.030***	-3.455***	-3.455**
	(0.699)	(0.782)	(0.709)	(0.794)	(0.667)	(1.024)	(1.318)
No College							
$\geq$ 15 days since SNAP * Income $<$ 60k	-0.002	0.000	0.001	0.003	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Start 2-Year							
$\geq$ 15 days since SNAP * Income $<$ 60k	0.008***	0.011***	0.004	0.006*	0.007**	0.008**	0.008*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Start 4-Year							
$\geq$ 15 days since SNAP * Income $<$ 60k	-0.007**	-0.011***	-0.004	-0.009***	-0.004	-0.007*	-0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
College Graduation Rate							
$\geq$ 15 days since SNAP * Income $<$ 60k	-0.3469***	-0.4112***	-0.1961	-0.2634*	-0.2684**	-0.3469**	-0.3469***
	(0.1151)	(0.1237)	(0.1267)	(0.1384)	(0.1123)	(0.1348)	(0.0933)
College Average SAT							
$\geq$ 15 days since SNAP * Income $<$ 60k	-2.7938***	-3.0620***	-1.2678	-1.4856*	-2.3212***	-2.7938**	-2.7938**
	(0.7047)	(0.7674)	(0.7833)	(0.8731)	(0.6730)	(1.0486)	(0.9887)
Selective							
$\geq$ 15 days since SNAP * Income $<$ 60k	-0.009**	-0.011***	-0.006*	-0.009**	-0.006*	-0.009**	-0.009***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.002)
Flagship							
$\geq$ 15 days since SNAP * Income $<$ 60k	-0.005**	-0.005**	-0.003	-0.003	-0.003	-0.005*	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Observations	427,940	427,387	394,982	394,482	427,940	427,940	427,940
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-by-DOM Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	No	Yes	No	Yes	Yes	Yes
Zip Fixed Effects	No	Yes	No	Yes	No	No	No
Test Fixed Effects	Yes	Yes	No	No	Yes	Yes	Yes
Opportunity Fixed Effects	No	No	Yes	Yes	No	No	No
Income Bin Controls	No	No	No	No	Yes	No	No
Cluster	SDC	SDC	SDC	SDC	SDC	SC	S

Notes: Estimates are based on data from The College Board on SAT scores and National Student Clearinghouse data on college attendance from 2009–2014. Estimates were produced by estimating Equation 2 using OLS. Controls include indicator variables for race, ethnicity, and gender. Income bin controls include indicator variables for household income bins as reported on the SAT survey by students. Standard errors are clustered on either the state-by-disbursement day-by-cohort level (SDC), state-by-cohort (SC) or state (S) level as indicated.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.