

Impact Evaluation of Intervene K-12 Tutoring on Grade 9 Mathematics Achievement in Hartford Public Schools

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December 2023



JOHNS HOPKINS
SCHOOL *of* EDUCATION

Center for Research and
Reform in Education

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EXECUTIVE SUMMARY

Impact Evaluation of Intervene K-12 Tutoring on Grade 9 Mathematics Achievement in Hartford Public Schools

Intervene K-12 contracted with the Center for Research and Reform in Education (CRRE) at Johns Hopkins University to conduct a quasi-experimental design (QED) study in Hartford Public Schools (HPS). The purpose of the present study was to evaluate the efficacy of Intervene K-12's online, small-group tutoring program on Grade 9 students in Hartford Public Schools (HPS) during the 2022-23 school year. The current study sample consisted of Spanish-speaking English Language Learners (ELLs) who had interruptions in their education. When considering the English learner population, ELLs face additional challenges as compared to their non-ELL peers, including not enough support within the classroom to support the bridge between L1 and L2; cultural and social biases in curricula; and lack of intervention in the ELL's schooling history (Gándara & Hopkins, 2010). As a result of these students' interruptions, study students were starting the 2022-23 school year with mathematics achievement scores several grade levels below average. Outcome variables for this evaluation included End-of-Course (EOC) and Final Algebra I exam scores, as well as PSAT mathematics scores.

Research questions for this study include:

1. How does participation in Intervene K-12 online tutoring impact student achievement in mathematics?
2. Does the level of program usage correlate to student achievement?

Research Design

This study was a quasi-experimental design (QED) that examined the impact of Intervene K-12 tutoring on mathematics achievement for Grade 9 ELL students identified by HPS as having experienced considerable learning disruptions as a result of the COVID-19 pandemic and having recently arrived in the United States. Achievement gains for treatment students, who received tutoring services, were compared to those of comparison students, who did not receive tutoring. Comparison students were selected by using propensity-score matching (PSM) techniques in order to identify students who were most similar to treatment students. The main outcome variables of interest were end-of-course (EOC) and Final Algebra I exam scores, as well as spring 2023 PSAT mathematics scores, while beginning-of-course (BOC) Algebra I exam scores and spring 2022 PSAT mathematics scores were used as prior mathematics achievement variables. Multiple regression analyses were used to examine the impact of Intervene K-12 tutoring on mathematics achievement gains.

Results

The results of the impact analyses showed generally positive mathematics achievement trends for Intervene K-12 tutoring students. Treatment students outgained matched comparison students on the EOY Algebra I exam by more than 7 points. Similarly, treatment students outgained comparison students on the spring PSAT math assessment by 5 points although these impacts did not reach statistical significance. The effect size of the EOC Algebra I score impact was nearly 0.40 SDs, indicating a medium-to-large practical impact of tutoring on student mathematics achievement.

Usage data, consisting of total tutoring time, indicated that tutored students in HPS spent an average of just under 10 hours of time receiving tutoring in the 2022-23 school year. However, considerable variance was observed in the distribution of tutoring time, with several students receiving 15 or more hours of tutoring and several others receiving two hours or less of tutoring. It is important to consider that Intervene's tutoring model in Hartford was for students to receive tutoring twice a week in 35-minute sessions. Pearson correlations between tutoring time and mathematics achievement outcomes were inconsistent in direction and weak in magnitude, with none of the associations reaching statistical significance. Regression analyses controlling for prior mathematics achievement and demographic variables also did not find any significant associations between total tutoring time and mathematics achievement variables.

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Intervene K-12 contracted with the Center for Research and Reform in Education (CRRE) at Johns Hopkins University to conduct a quasi-experimental design (QED) study in Hartford Public Schools (HPS). The purpose of the present study was to evaluate the efficacy of Intervene K-12's online, small-group tutoring program on Grade 9 students in Hartford Public Schools (HPS) during the 2022-23 school year. The current study sample consisted of Spanish-speaking English Language Learners (ELLs) who had experienced learning interruptions. Beginning-of-Course (BOC), End-of-Course (EOC) and Final Algebra I exam scores, as well as PSAT mathematics scores, were examined in this evaluation.

Intervene K-12 offers a comprehensive intervention system that combines advances in learning science, intervention best practices, and smart technology to drive measurable improvement in student outcomes. Intervene K-12's services address the following key areas:

- Student academic growth and success
- Building student confidence and inspiring ownership of their learning
- Providing teachers and administrators with tools for efficient and effective intervention
- Equipping educators to accurately identify student gaps by diagnosing misconceptions
- Providing administrators with real-time data to inform instructional effectiveness

Intervene K-12's online tutoring platform allows students to access live, small-group tutoring before, during, or after the school day. Intervene K-12 follows a data-driven tutorial model. Tutorials start with an assessment of skills. Students are then organized into small groups with similar skills gaps including misconceptions and distractors. Groups are then assigned a course of study to close gaps based on targeted objectives aligned to rigorous college and career-ready standards. For ongoing progress monitoring, Intervene K-12 schedules a sequence of data reviews and feedback sessions with school and district stakeholders, highlighting the importance of using data to make decisions in further tutoring sessions (Foegen, 2009). During these sessions, Intervene K-12 provides data and insights, requests feedback on instruction, shares student feedback, and adjusts delivery as needed to support district goals. Intervene K-12 provides teachers and administrators with dashboards for real-time reporting in-between data reviews. Finally, Intervene K-12 conducts post-implementation evaluations to validate the impact of the services delivered.

Regarding specific implementation at HPS, students were engaged in tutorials between November 11, 2022, and May 25, 2023. Intervene K-12 collaborated with Hartford Public High School (HPS) leadership regarding different needs for the targeted group of students identified. This sample group of students included ELLs who were not on track to meet Algebra I standards. HPS communicated to Intervene K-12 that many of these students had potential interruptions in their education as a result of being newcomers to the United States. Additional background data for the student sample were provided. Intervene K-12 established students' initial academic levels and tailored courses to meet their academic needs. Intervene K-12 paused the engagement to re-align with the campus to ensure students and teachers' needs and goals were met. The treatment students' teachers were asked to provide mathematics grade placements for each student. Intervene K-12 developed assessments aligned to HPS teacher assignments, encompassing three grade levels of curriculum standards. For example, if students were assigned to Grade 8 by the HPS teacher, they were given an assessment that asked questions from Grades 7-9 concepts. These assessments aimed to evaluate students' existing knowledge and identify areas that required further instruction.

Students were provided Intervene K-12 assessments December 15 through December 20, 2022. Following the assessment process, students were placed in specific grade-level courses determined by a combination of assessment scores and teacher-assigned grade levels. These courses spanned Grades 4-9 and were designed as accelerated programs. Students would go over a standard in one or two sessions instead of three (which is Intervene K-12's established sequence). This accelerated approach allowed students to grasp concepts in fewer sessions, enabling Intervene K-12 to address gaps in students' knowledge swiftly and for students to progress more rapidly. Furthermore, these courses were conducted bilingually, offering students the opportunity to engage with concepts in English while establishing connections to their existing understanding in Spanish.

Research questions for this study include:

1. How does participation in Intervene K-12 online tutoring impact student achievement in mathematics?
2. Does the level of program usage correlate to student achievement?

Method

Research Design

This study was a quasi-experimental design (QED) that examined the relationship between Intervene K-12 tutoring and mathematics achievement for Grade 9 ELL students identified by HPS as having experienced considerable learning disruptions.

Achievement gains for treatment students, who received tutoring services, were compared to those of comparison students, who did not receive tutoring. It is important to note that matched comparison students were not specifically identified as having learning disruptions, as data did not permit this identification. Comparison students were selected by using propensity-score matching (PSM) techniques to identify students who were most similar to treatment students.

The main outcome variables of interest were spring and EOC Algebra I course exam grades, as well as PSAT mathematics scores. Regression analyses were used to examine the impact of Intervene K-12 tutoring on mathematics achievement gains.

Participants

Participants included HPS Grade 9 students identified by the school district as needing supplemental instructional services to accelerate learning. Intervene K-12 provided CRRE at Johns Hopkins University with a list of the 47 HPS Grade 9 ELL students who participated in high-dosage tutoring services. Forty-two of these IDs merged with IDs found in student achievement files provided to CRRE by HPS. Demographics for treatment students and comparison students with at least one set of pretest and posttest scores are found in Table 1. Student demographics for the propensity-matched comparison students are shown in this table.

Table 1

Student Characteristics of Analytic Sample

Demographic	Treatment	Comparison (All)	Matched Comparison
% Hispanic	88.24	51.79*	84.91
% Black	8.82	36.35*	7.55
% White	2.94	7.33	3.77
% Other Race	0.00	4.37	3.77
% Female	64.71	48.52*	43.40*
% Economically disadvantaged	61.76*	81.75	81.13
% Special Education	5.88	8.58	13.21
% ELLs	76.47	17.16*	77.36
<i>N</i>	34	641	53

Note. * $p < .05$; comparisons were made separately between treatment group and each comparison group (all and matched).

Treatment students were largely Hispanic and ELLs, while the comparison pool of students consisted of significantly smaller percentages of these students, smaller percentages of female students, and significantly larger percentages of Black students. The matched comparison group contained similar percentages of Hispanic and ELL

students, but still contained a significantly larger percentage of economically disadvantaged students and a significantly smaller percentage of female students.

Measures

Algebra Course Exams. HPS administers Course Algebra I exams to Grade 9 students currently taking Algebra I. The exam is administered four times each year: in the fall, winter, and spring, as well as a cumulative final exam administered at the end of the school year. Student performance is reported as the percentage of correct responses on each assessment. The fall exam score was used as the pretest measure, while both the spring and final exam scores were used as posttest measures, due to the different (cumulative) nature of the final exam.

PSAT Mathematics (PSAT). PSAT Mathematics scores from the fall and spring of the 2022-23 school year were also used in this evaluation. According to The College Board, the PSAT math exam includes 44 questions evenly divided between two sections, with 35 minutes available for students to complete each section. The PSAT math exam focuses on key elements of algebra, advanced math, problem solving, data analysis, geometry, and trigonometry. HPS provided overall PSAT math scores, which can range between 120-720. Nearly all students in this evaluation scored in the lowest PSAT math score band, which contains scores between 120 and 420.

Tutoring usage data. Intervene K-12 provided CRRE with total tutoring time for each student. These times were provided in terms of hours, minutes, and seconds; for analysis, all times were converted to minutes.

Demographics. HPS provided CRRE with a series of student-level demographic variables, including gender, ethnicity, special education status, ELL status, and free/reduced lunch eligibility. These variables were contained in the achievement data file provided to CRRE by HPS and were recoded into a series of dummy variables for use in propensity-score matching and regression analyses.

Analytical Approach

Data for all study students were analyzed descriptively by examining patterns in mathematics achievement scores and time in tutoring. Pearson correlations between tutoring time and each of the three main outcome variables were computed. Multiple linear regression approaches were used to determine Intervene K-12 tutoring impacts on Grade 9 students in HPS. Demographic variables including gender, ethnicity, economically disadvantaged status, and special education status were included in all analytic models.

To adjust for prior achievement and demographic differences between treatment and comparison groups, propensity score matching (PSM) was used to create

comparison groups of schools that were as similar as possible to treatment schools. Propensity scores were computed using the `psmatch2` command in Stata (v 17.0), with one-to-one matching using the Mahalanobis distance metric. This procedure created a comparison group that was of equal size to the treatment group and, based on prior achievement and ELL status, as similar as possible to treatment students. The result of the PSM procedure was that treatment students were individually matched with comparison students, allowing for a stronger comparison between treatment and comparison students, given the very specific nature of treatment students in this study.

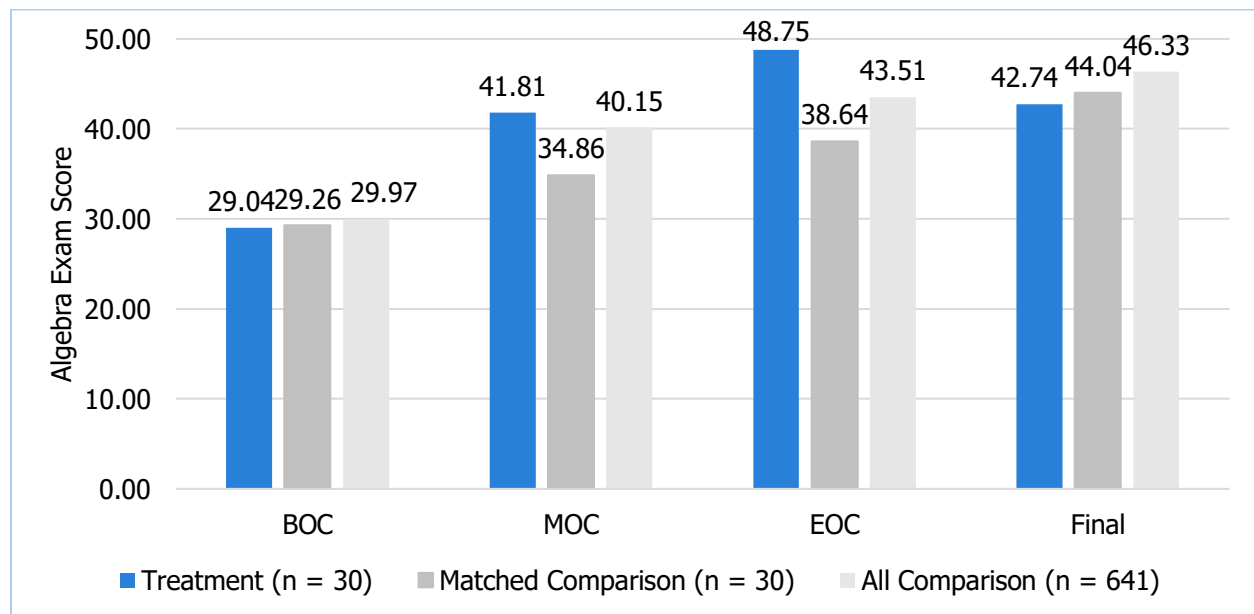
Results

We begin by descriptively examining unadjusted patterns of mathematics achievement gains for treatment and comparison students. We also examine average tutoring time for treatment students. This is followed by multiple regression analyses of the impact of Intervene K-12 tutoring on mathematics achievement gains.

Mathematics achievement patterns. Figure 1 shows average Algebra I course exam scores for treatment and comparison students at all four administrations. We provide average scores for all comparison students, as well as for propensity-matched comparison students.

Figure 1

Average Overall Algebra I Exam, by Test Administration



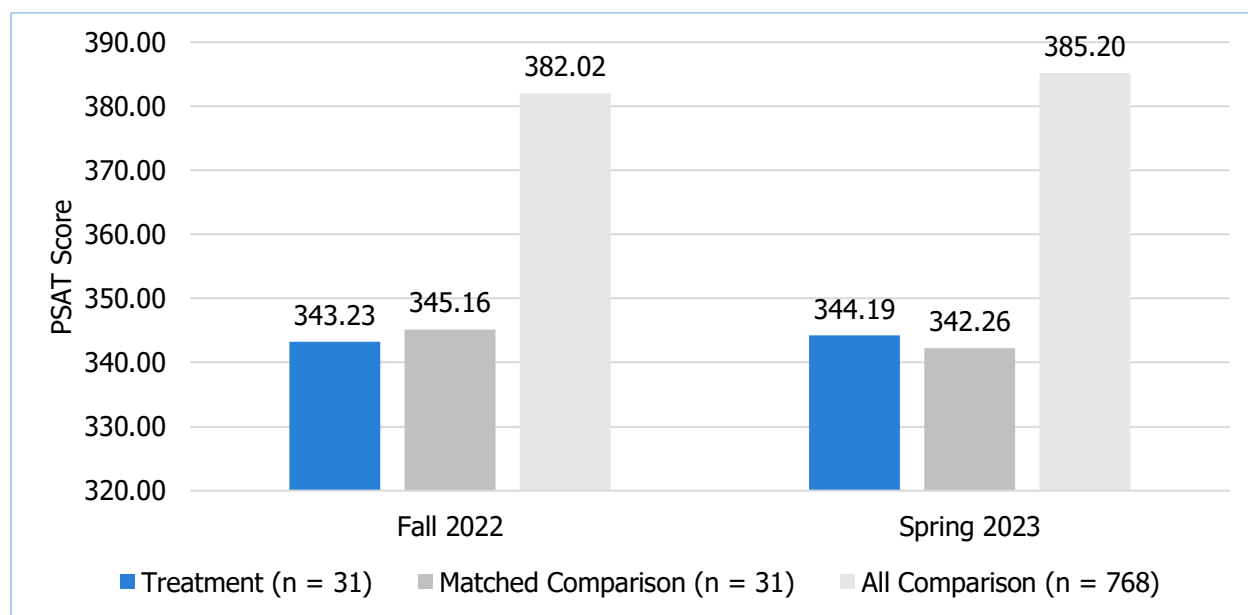
Note. Only students with non-missing BOC, EOC, and Final exam scores are included in this analysis.

Both treatment and comparison students averaged scores of just under 30 points on the BOC exam. Treatment students averaged nearly 20-point gains from BOC to EOC and nearly 14-point gains from BOC to final exam, while matched comparison students averaged nearly 10-point gains from BOC to EOC and nearly 15-point gains from BOC to final exam. Thus, tutoring impacts appeared to be more positive on EOC Algebra scores than on final Algebra exam scores.

We next examine PSAT mathematics scores descriptively. Figure 2 shows unadjusted fall and spring PSAT scores from treatment and comparison students.

Figure 2

Average PSAT Mathematics Scores, by Administrations



Note. Only students with non-missing PSAT mathematics scores are included in this analysis.

Slightly positive student progress was evidenced on PSAT mathematics scores from fall to spring for students who received tutoring as compared to the matched comparison group, who slightly regressed. Treatment students averaged approximately 1-point gains, while matched comparison students averaged nearly 3-point drops from fall to spring. These results show a slight positive impact of tutoring on PSAT mathematics scores.

Tutoring time. Table 2 shows the average total time treatment students participated in Intervene K-12 tutoring services. Only students who took the end of year assessments, with at least one non-missing outcome (Algebra or PSAT score) were included in this analysis.

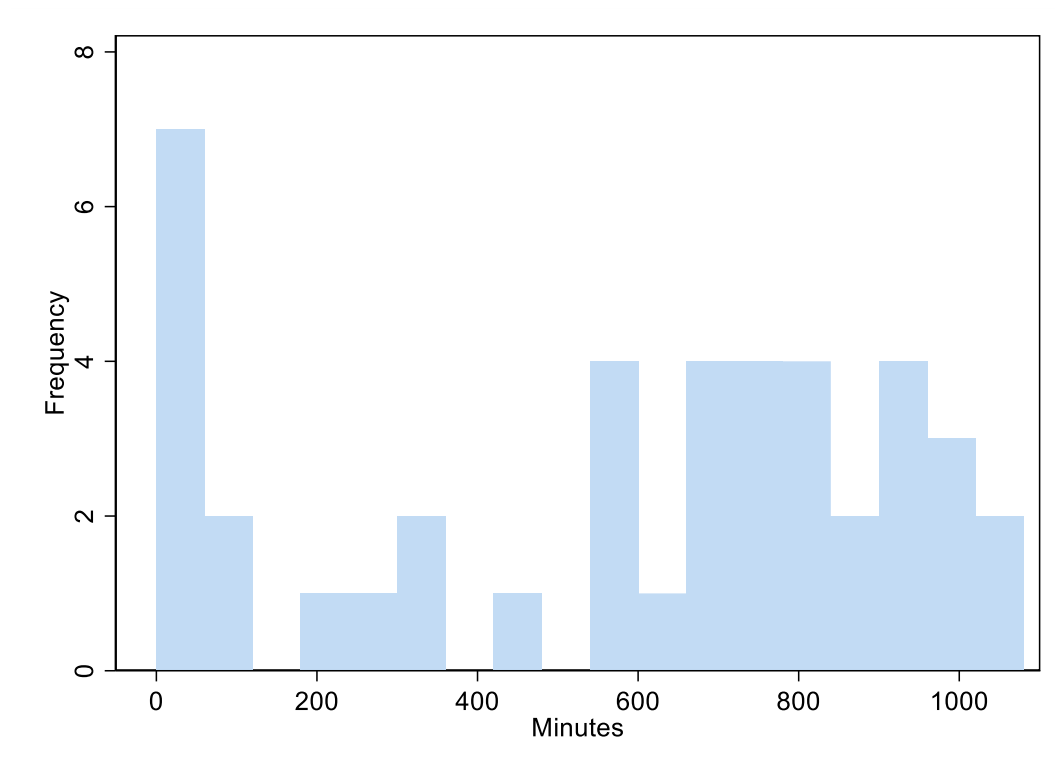
Table 2

Average Tutoring Time

Mean	SD	Min	Max	N
576.76	346.58	2	1051	42

Note. Individual student times were rounded to the nearest minute.

Treatment students averaged nearly 577 minutes, or just under 10 hours, of total tutoring time throughout the school year. However, there was considerable variation in tutoring, with total time estimates ranging from as little as two minutes to as much as 17.5 hours. According to Intervene K-12, HPS elected to implement tutoring in two 35-minute sessions each week. Closer inspection of tutoring time data revealed a bimodal distribution. Some cohort students were clustered between 10-15 hours of tutoring time received while another cluster of other cohort students participated in two hours or less of total tutoring time. Figure 3 shows the distribution of total tutoring time for students with at least one non-missing outcome variable.

Figure 3*Histogram of Total Tutoring Time, in Minutes*

Additionally, we examined unadjusted associations between total tutoring time and mathematics achievement outcome variables. This allowed us to examine the degree to which total student tutoring time was related to EOC and Final Algebra exam

scores, along with spring 2023 PSAT scores. Table 3 shows the Pearson correlations between total tutoring time and each of the three main outcome variables. Note that only observations with non-missing pretest and posttest data for each measure were included in these analyses.

Table 3*Pearson Correlations Between Tutoring Time and Mathematics Achievement*

Outcome Measure	<i>r</i>	<i>p</i> value	<i>N</i>
EOC Algebra	+.26	.165	30
Final Algebra	+.05	.795	30
Spring PSAT	-.02	.942	31

Associations between total tutoring time and mathematics achievement outcomes were inconsistent in direction and generally weak in magnitude. None of the associations reached statistical significance.

Impact Analyses

In this section, we overview the results of the main achievement analyses examining the impact of Intervene K-12 tutoring on mathematics achievement gains. We consider each of the three outcomes separately. Table 4 shows the results of analyses examining Intervene K-12 impacts on EOC Algebra I scores. Each analysis controls for demographic variables including race/ethnicity, gender, special education status, and Free and Reduced Meal Status (FARMS) status.

Table 4*Impact Analysis of Intervene K-12 Tutoring on EOC Algebra I Scores*

Variable	Estimate	Standard Error	<i>p</i> value	Effect Size
Intervene K-12 Tutoring	7.312	4.382	.101	0.39
Constant	39.889***	2.929	<.001	
<i>N</i>	60			

Note. *** $p < .001$.

The impact of tutoring on EOC Algebra I scores was directionally positive but did not reach statistical significance ($p = .101$). The regression estimate can be interpreted as the impact on BOC to EOC Algebra I score gains for treatment students, in relation to comparison students. Thus, Intervene K-12 tutoring students outgained matched comparison students by more than 7 points from BOC to EOC. The observed effect size was nearly 0.4 SDs, indicating a medium-to-large practical impact of tutoring on EOC

Algebra I scores. The effect size evidenced here is notable, as mathematics program impacts generally average slightly more than 0.1 SDs (Kraft, 2020). The lack of statistical significance was most likely due to the small sample size of the treatment group, resulting in an under-powered regression analysis.

Table 5 shows the results of a similar analysis examining the impact of Intervene K-12 tutoring on final Algebra I exam scores. The same matched students were used in this analysis, and BOC Algebra I scores were again used as the prior achievement control variable. Similarly, the same demographic variables were also included in this analysis. The sample size is slightly smaller in this analysis, due to missingness on the final exam variable that was not present on the EOC score variable.

Table 5

Impact Analysis of Intervene K-12 Tutoring on Final Algebra I Scores

Variable	Estimate	Standard Error	<i>p</i> value	Effect Size
Intervene K-12 Tutoring	-5.817	5.285	.277	-0.27
Constant	46.337***	3.555	<.001	
<i>N</i>	57			

Note. *** $p < .001$.

No significant impact of Intervene K-12 tutoring on final Algebra I exam scores was observed. The regression estimate can be interpreted similarly to the prior analysis; thus, comparison students outgained treatment students by nearly 6 points from BOC to final Algebra exam score. It is important to note that the final exam is cumulative in nature, while the BOC, MOC, and EOC assessments functioned more as progress monitoring assessments. This may help to explain differences in directionality between the EOC and final Algebra I score analyses.

Table 6 shows the results of the analysis examining the impact of Intervene K-12 tutoring on spring 2023 PSAT math scores. A different matched comparison group was used here, based on fall 2022 PSAT math scores and ELL status. Fall 2022 PSAT math scores were used as the prior achievement variable, and the same demographic variables from prior analyses were used in this analysis.

Table 6

Impact Analysis of Intervene K-12 Tutoring on Spring 2023 PSAT Math Scores

Variable	Estimate	Standard Error	<i>p</i> value	Effect Size
Intervene K-12 Tutoring	5.114	17.128	.779	0.07

Constant	341.153***	12.505	<.001
<i>N</i>	62		

Note. *** $p < .001$.

A small nonsignificant positive impact of Intervene K-12 tutoring was evidenced on spring 2023 PSAT math scores. The regression estimate can be interpreted similarly to those in previous analyses. Thus, treatment students outgained comparison students by approximately 5 points from fall 2022 to spring 2023 on the PSAT math assessment. The observed effect size of .07 SDs indicates a small practical impact of tutoring on PSAT math scores. Thus, PSAT math score trends were similar for both treatment and comparison students, with a slight advantage observed for treatment students.

Usage regression analyses. We also conducted a series of regression analyses examining the impact of total tutoring time on each of the mathematics achievement outcome variables. These regression analyses were similar to those used in the impact analyses, with the treatment variables switched out with a measure of total tutoring time. This allowed us to examine the impact of different “dosages” of tutoring time on achievement gains, while allowing for prior mathematics achievement and demographic controls. These analyses were only conducted for treatment students. The results of these analyses can be found in Table 7.

Table 7

Associations Between Total Tutoring Time and Mathematics Achievement

Assessment	Estimate	Standard Error	p value
EOC Algebra I score ($n = 30$)	0.004	0.009	.695
Final Algebra I score ($n = 30$)	-0.004	0.011	.733
Spring 2023 PSAT Math ($n = 31$)	0.050	0.054	.355

Total tutoring time was not significantly associated with any of the mathematics achievement outcome variables, after controlling for prior mathematics achievement and demographics. The regression estimates can be interpreted as the expected gain in an outcome score for each minute of tutoring. For example, every minute of tutoring was associated with a .05-point gain in spring 2023 PSAT math score, and every minute of tutoring was associated with a .004-point increase in EOC Algebra score. An alternative interpretation is that 20 minutes of tutoring was associated with a 1-point gain in spring 2023 PSAT math score, while 250 minutes of tutoring was associated with a 1-point gain in final EOC Algebra I score. This is computed by simply taking the reciprocals of each regression estimate to determine the number of minutes associated with a 1-point gain on an outcome variable. Similar to the Pearson correlations previously conducted, no significant associations between tutoring time and mathematics achievement were found.

Summary & Discussion

The purpose of this evaluation was to conduct an efficacy study using a quasi-experimental design (QED) in Hartford Public Schools to examine the impact of Intervene K-12's tutoring program on the mathematics achievement of Grade 9 ELL students who had experienced learning disruptions prior to the 2022-23 school year. Mathematics achievement data for treatment students and propensity-matched comparison students were examined in the main impact analyses, along with usage data from Intervene K-12, which consisted of total tutoring time for each student. Multiple linear regression was used to determine program impacts on each outcome variable of interest.

Results from the main impact analyses showed that achievement trends tended to favor treatment students, although none of these impacts reached statistical significance. The most promising findings were present in the BOC to EOC Algebra I score analyses, where treatment students outgained matched comparison students by more than 7 points ($p = .101$). This impact, while not statistically significant, resulted in an effect size of nearly .40 SDs, indicating a medium to large practical effect of tutoring on mathematics achievement gains. Results were more equivocal on spring 2023 PSAT math and final Algebra exam scores, with treatment students outgaining comparison students by 5 points on the PSAT math assessment and comparison students outgaining treatment students by nearly 6 points on the final Algebra assessment. The differing nature of the assessments may help to explain the differing results across outcomes. Specifically, EOC Algebra I is a progress monitoring assessment, while the final Algebra exam is a cumulative assessment, and the PSAT is a college readiness assessment.

Descriptive usage analyses showed that Intervene K-12 tutoring students generally spent around 10 hours receiving tutoring, on average. However, there was considerable variation in the distribution of tutoring hours, with some students receiving upward of 17-18 hours of tutoring and other students receiving less than two hours of tutoring. Pearson correlations between total tutoring time and mathematics achievement variables showed no significant associations between tutoring time and mathematics scores. Similarly, regression models controlling for prior mathematics achievement and demographic variables found no significant associations between total tutoring time and mathematics achievement.

In interpreting the results of this study, some important limitations need to be considered. First, the study sample for this study is very idiosyncratic, as the focus was Grade 9 ELL students in HPS that had experienced learning disruptions in previous school years, as a result of the COVID-19 pandemic and having recently arrived in the United States from other countries. Thus, results from this study may not generalize to other student populations or settings. In addition, given the special characteristics of the tutored students, the study sample was very small. The small sample size resulted

in underpowered analyses that may not have detected important differences in achievement trends between treatment and comparison students. This is most apparent in the EOC Algebra I score analyses; even though an effect size of nearly 0.40 SDs was observed, which is a medium-to-large practical effect and larger than mean effect sizes in small-sample randomized control trials of mathematics interventions (Kraft, 2020), significance was not reached. Given the specific nature of the targeted treatment group here and unknown conditions regarding the focuses of the tutoring relative to the various achievement assessments analyzed at different times of the year, interpretations regarding program efficacy need to be made cautiously.

It is important also to consider the nature of the comparisons between tutoring students, in relation to matched comparison students. While tutoring students were matched to comparison students on the basis of prior mathematics achievement and available demographic data, it is very possible that comparison students, while similar to tutoring students on prior achievement and demographics, were still quite substantively different from tutoring students, especially in terms of prior educational experiences. For example, it is unknown whether the matched comparison students experienced learning disruptions similar to those experienced by tutoring students in this study. Thus, results of this study, especially relating to EOC Algebra and PSAT mathematics scores, may be interpreted as a step toward beginning to close achievement gaps between low-achieving ELL students who are new to the country and native learners. Further research with a larger sample and broadening of outcome measures to include affective student outcomes (e.g., motivation and self-efficacy) in addition to mathematics achievement is encouraged in order to provide more fine-grained, precise comparisons between tutored and non-tutored students, across a variety of different student contexts.

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