COVID Impact on Education Outcomes

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Introduction

The mandatory shutdown of in-person learning across the United States in March of 2020 due to the COVID-19 pandemic has created deep concern about the long term impacts on school aged children. While it is important to understand the impact the pandemic and our response as a society has had on the social and emotional well-being of students, this study will focus on the effect on academic achievement and growth due to losses in instructional time.

Early predictions, such as a report from NWEA (Kuhfeld et al., 2020), suggested that a COVID 'slide' in achievement would result in learning gains in reading that would amount to approximately 70% of what we would expect in a typical year. In mathematics the predictions were more dire. The average gain was expected to be only 50% of a typical year and in some grades the average gain would be a full grade level behind.

Indeed, initial reports on learning outcomes in the fall of 2020 indicated that there were broad declines in mathematics achievement due to COVID related loss of learning opportunities (see for instance, our reports this fall). Those same reports suggested that, on average, losses in reading were minimal. Specifically, the student population entering the 2020-21 school year at CMU-authorized schools who took the NWEA MAP Assessment demonstrated school level average achievement levels in reading that were consistent with cohorts in previous school years. In mathematics, school level averages were significantly lower but not as low as predicted by the NWEA report. This is not to say that the NWEA predictions were poor. Considerable uncertainty was calculated and expressed by the authors. The authors point out, in fact, that the top third of students in their sample were projected to make gains in reading beyond what is typically expected.

The fall 2020 reports provided a basis for cautious optimism about the ability of students, parents, and educators to navigate successfully a set of very difficult circumstances and provide meaningful learning opportunities for students. The caution around that optimism should be clarified. Absent from the fall 2020 reports on student achievement were analyses of demographic differences in achievement and growth. Specific questions about differences in learning loss across demographic groups were not the focus of those early reports. These types of questions require more sophisticated methods and careful analysis which can be time consuming.

Despite well constructed estimates of learning expectations, entering the 2020-2021 school year little was known regarding the actual achievement status of students. Thus, early Center reports and results from NWEA focused on robust estimates of student achievement levels to assist educators and parents in responding to students' immediate academic needs. Individual estimates addressed this need for teachers in the classroom while school level aggregates gave a first glance at overall trends to school leads and policy makers.

Now, we turn our attention to group level differences and the large variation in the impact of COVID-based learning loss. Measures of central tendency such as means and medians give us a sense of the typical impact but they do not convey how impacts vary across the student population. Specifically, they do not convey whether or not students from different demographic backgrounds share the 'typical' response.

Store (2021) explores this same set of questions with respect to achievement status. Normative status is often reported as a student's percentile rank on the assessment in question. Store explores changes in achievement status by examining changes in percentile rank category across grade level and demographic groups. These changes in status are then compared to pre-COVID school years and differences across school years are tested for statistical significance. Overall, Store finds that student achievement status declined in the 2019-2020 school year. That is, more students were 'sliders' than in pre-COVID school years. Sliders are defined as students who move down in Achievement Status Category. These declines are more pronounced in mathematics than in reading. This is consistent with school level results found in early Center published Academic Performance Reports.

Store brings additional insight into whether or not these declines are consistent across demographic groups. In general, early grades see more sliders in mathematics. Additionally, Free and Reduced Lunch (FRL) eligible students were more likely to be a slider in mathematics. Beginning achievement status also plays a role. Lower achieving students are more likely to slide than their high achievement counterparts. All racial demographic groups see a large rise in the number of sliders. In reading, the impacts are similar but much smaller in magnitude. One exception is a larger proportion of black students sliding in reading.

This study adds to previous research in several important ways. First, we examine the affect of COVID related learning loss on growth. Other studies, such as Store, focused on achievement status. Second, we model the expected growth of students conditional on grade, race/ethnicity, FRL eligibility, and beginning achievement status simultaneously. Third, we focus on the variability in COVID related learning loss more directly. Previous research implies there is variability across demographic groups. We seek to make that variability explicit. Fourth, we employ a multilevel piecewise growth model to estimate the change in academic growth trajectories due to the COVID pandemic.

Specifically, this analysis addresses the following questions:

1. Is FRL eligibility and/or student race/ethnicity associated with average differences in COVID-based learning loss?
2. How have student achievement trajectories changed since the pandemic was declared?

The report is organized as follows:

1. Data and Statistical Summaries
2. Single level models are presented with Fall-to-Fall growth scores as the outcome.
3. Multilevel piecewise models estimate the change in academic growth due to COVID.
4. Summary

Data and Statistical Summary

The master data file for this study is compiled from administrative and performance data on CMU's portfolio of charter school students from the 2018-2019, 2019-2020, and 2020-2021 school years. Academic performance is measured by the fall administration of NWEA's MAP assessment in both reading and mathematics. Typically, spring scores would be included in an analysis such as this. However, the government imposed shutdown of schools in the spring of 2020 due to the COVID-19 pandemic lead to no standardized tests being administered at that time. Thus, spring 2020 scores are missing for all students. Therefore, we consider fall-to-fall growth as our outcome measure.

This has several implications for our analysis. First, all analysis, including cross-sectional analysis, includes students who were in multiple grades for the analysis period. For instance, when we analyze student performance for grade 3 students in the 2018-2019 school year, we treat the fall 2018-2019 assessment as the 'starting score' and the fall 2019-2020 assessment as the 'final score'. Note that this means our grade 3 students are in the fall of 4th grade when they take the second assessment. Thus, academic growth between these points includes both school based learning time and any change in achievement associated with the summer break. For the 2019-2020 school year (which we refer to as the COVID year), fall-to-fall growth includes school based learning, the loss of school based learning due to the shutdown and the summer break.

We point this out in light of research from Kuhfeld, Condron, and Downey (2020) which indicates that racial/ethnic achievement gaps between Black and White students typically grow during the school year and shrink over the summer. The same report indicates that the Hispanic-White achievement gap appeared to shrink over time but lacked a consistent seasonal trend. The Asian-White gap grew during summer breaks with Asian students seeing a distinct advantage in out-of-school learning, particularly in mathematics. Additionally, internal research at The Center for Charter Schools using multiple assessment periods within a school year have indicated that school based learning is non-linear. That is, academic growth is stronger between the fall and winter assessment than the winter and spring assessment. Kuhfeld et al. (2020) utilize this same assumption in their prediction models by including a quadratic growth parameter to capture differences in learning rates throughout the year. Thus, we note that fall-to-fall growth is a linear approximation of academic growth. The true gap between groups may widen or shrink over the school but fall-to-fall growth captures the average change.

We are, however, able to capture non-linear growth across school years for student cohorts. That is, we can follow students across three grade levels with our dataset. This allows us to estimate a structural break in the learning rates due to the COVID pandemic. This is accomplished in the second analytic portion of the study where we employ a piecewise growth model.

The master data file contains students who began grade 3 in 2018-2019 through students who began grade 8 in the 2020-2021 school year. This allows us to take subsets of data to answer variations on our research questions. Two variations are of particular interest. In the first, we compare cross-sections of students by grade level pre-COVID and during COVID. For example, we compare students who experienced grade 3 in 2018-2019 to students who experienced grade 3 in 2019-2020.

The composite data files received from NWEA contain not only the students' MAP scores and associated metrics but also a self-identified race/ethnicity flag. From this variable, race/ethnicity is designated into the following categories:

- American Indian or Alaska Native
- Asian
- Black or African American

- Hispanic or Latino
- Multi-ethnic
- Native Hawaiian or Other Pacific Islander
- White

The NWEA race/ethnicity variable does contain a considerable number of missing observations. To ‘fill-in’ gaps in the data and to obtain a measure of Free and Reduced Lunch Eligibility (FRL), we merge the NWEA dataset with data from the Michigan Student Data System (MSDS). MSDS records student race/ethnicity based on a seven-digit code which is capable of reflecting more nuance in how students identify with respect to their racial and ethnic heritage. The Center for Educational Performance (CEPI) provides guidance (CEPI, 2010) to convert the seven digit code into categories which are used by federal agencies and are essentially identical to the NWEA categories above.

After converting the MSDS code to a race/ethnicity variable that is compatible with the NWEA variable we find that there is considerable inconsistency for the American Indian, Native Hawaiian, and Multi-ethnic categories. Sullivan (2021) explores this inconsistency and recommends grouping American Indian, Native Hawaiian, and Multi-ethnic categories into one ‘Other’ category to improve inter-rater reliability. We follow that recommendation throughout this analysis. The result is a five category race/ethnicity category as follows:

- Asian
- Black or African American
- Hispanic or Latino
- Other
- White

A description of the data subsets used in the cross-section analysis are found in Tables 1 and 2. The first subset provides a count of students who were in 3rd, 4th, 5th, 6th, or 7th grade in the fall of 2018-2019 by FRL eligibility and by race/ethnicity. The second subset describes a cross-section of students who were in 3rd, 4th, 5th, 6th, or 7th grade in the fall of 2019-2020. The first subset we refer to as our pre-COVID cross-section. The second subset (Table 2) is our COVID-year cross-section.

Table 1. Pre-COVID (2018-2019)

	Non FRL					FRL				
Grade	**Asian**	**Black**	**Hispanic**	**Other**	**White**	**Asian**	**Black**	**Hispanic**	**Other**	**White**
3	85	220	41	53	453	25	858	90	115	308
4	85	226	36	27	428	30	802	84	113	288
5	70	184	46	78	493	25	689	89	124	352
6	63	219	48	100	477	28	685	89	97	357
7	71	175	51	83	485	12	584	74	101	382

Table 2. COVID (2019-2020)

	Non FRL					FRL				
Grade	**Asian**	**Black**	**Hispanic**	**Other**	**White**	**Asian**	**Black**	**Hispanic**	**Other**	**White**
3	86	196	38	97	381	31	839	143	217	356
4	76	211	38	111	384	25	765	144	215	344
5	70	207	41	86	349	30	721	139	167	347
6	54	222	41	104	425	23	681	124	158	332
7	52	215	44	121	415	24	600	101	168	331

Our second variation is a cohort analysis. Here, we follow students who were in grade 3 in 2018-2019, grade 4 in 2019-2020, and grade 5 in 2020-2021. We will refer to this group of students as focal grade 4. Grade 4 is the middle grade in the panel of data which also coincides with the COVID school year. This panel data approach allows us to explore how the COVID pandemic affected the learning rate of particular students. We also follow a upper grade level cohort who began grade 6 in 2018-2019, grade 7 in 2019-2020, and grade 8 in 2020-2021. We refer to this group of students as focal grade 7. These data subsets are described in contingency Tables 3 and 4.

Table 3. Focal Grade 4

FRL Eligibility	**Asian**	**Black**	**Hispanic**	**Other**	**White**
No	52	55	17	11	226
Yes	12	426	66	17	140

Table 4. Focal Grade 7

FRL Eligibility	**Asian**	**Black**	**Hispanic**	**Other**	**White**
No	39	67	21	10	249
Yes	14	320	51	18	161

From Separate to Combined Analysis

To understand how learning loss due to the COVID pandemic may have affected demographic groups differently we can rely on a linear model that estimates the expected fall-to-fall growth from fall of 2019 to fall of 2020. Then we can estimate the expected fall-to-fall growth from the fall 2018 to fall 2019, a non-COVID year, and compare the marginal effects for each demographic group.

The model we estimate is of the following form:

$$Growth = \hat{\beta}_0 + \hat{\beta}_1 * StartingScore + \hat{\beta}_2 * FRLEligibility + \hat{\beta}_3 * Asian + \hat{\beta}_4 * Black + \hat{\beta}_5 * Hispanic + \hat{\beta}_6 * Other + \hat{\beta}_7 * FRL/Asian + \hat{\beta}_8 * FRL/Black + \hat{\beta}_9 * FRL/Hispanic + \hat{\beta}_{10} * FRL/Other + e$$

There are several important things to note before we continue. First, we will analyze each grade independently. Expected growth in 3rd grade is higher in terms of RIT score than say 5th grade. In fact, expected growth in terms of RIT score decreases, on average, as students progress through grade levels. Analyzing grades separately allows us to make a reasonable comparison between the pre-COVID school year and the COVID impacted school year.

Second, we will include the students' RIT score from the first fall of the analysis period in the model. That is, for the COVID year where fall-to-fall growth is the fall 2020 score minus the fall 2019 score we will include the fall 2019 score as a covariate. Likewise, we will include the fall 2018 score in the pre-COVID year model. Just as growth in RIT terms is dependent upon grade, growth is also dependent on a student's initial status. Generally, a lower starting point is associated with a larger growth score in RIT (nominal) terms.

To understand why it is important to estimate a model which includes all of these categories simultaneously we can first explore two simplified models that only consider FRL eligibility and race/ethnicity separately. We will consider mathematics during this exercise but the same concept applies to our reading results. We will still include the students' starting score (RIT Score in the first fall) as a control. This means that we will interpret the marginal effect as the expected growth of a student scoring at the mean (or average) of all students in the grade being considered.

We proceed by examining the expected growth in RIT terms for mathematics in grades 3, 4, and 5 respectively. First, we estimate using only staring score and FRL eligibility. The left column is from the school year 2018-2019 (fall 2018 to fall 2019 growth). The right column is from the school year 2019-2020 (fall 2019 to fall 2020 growth) which was impacted by the COVID related shutdown on schools in the spring of 2020.

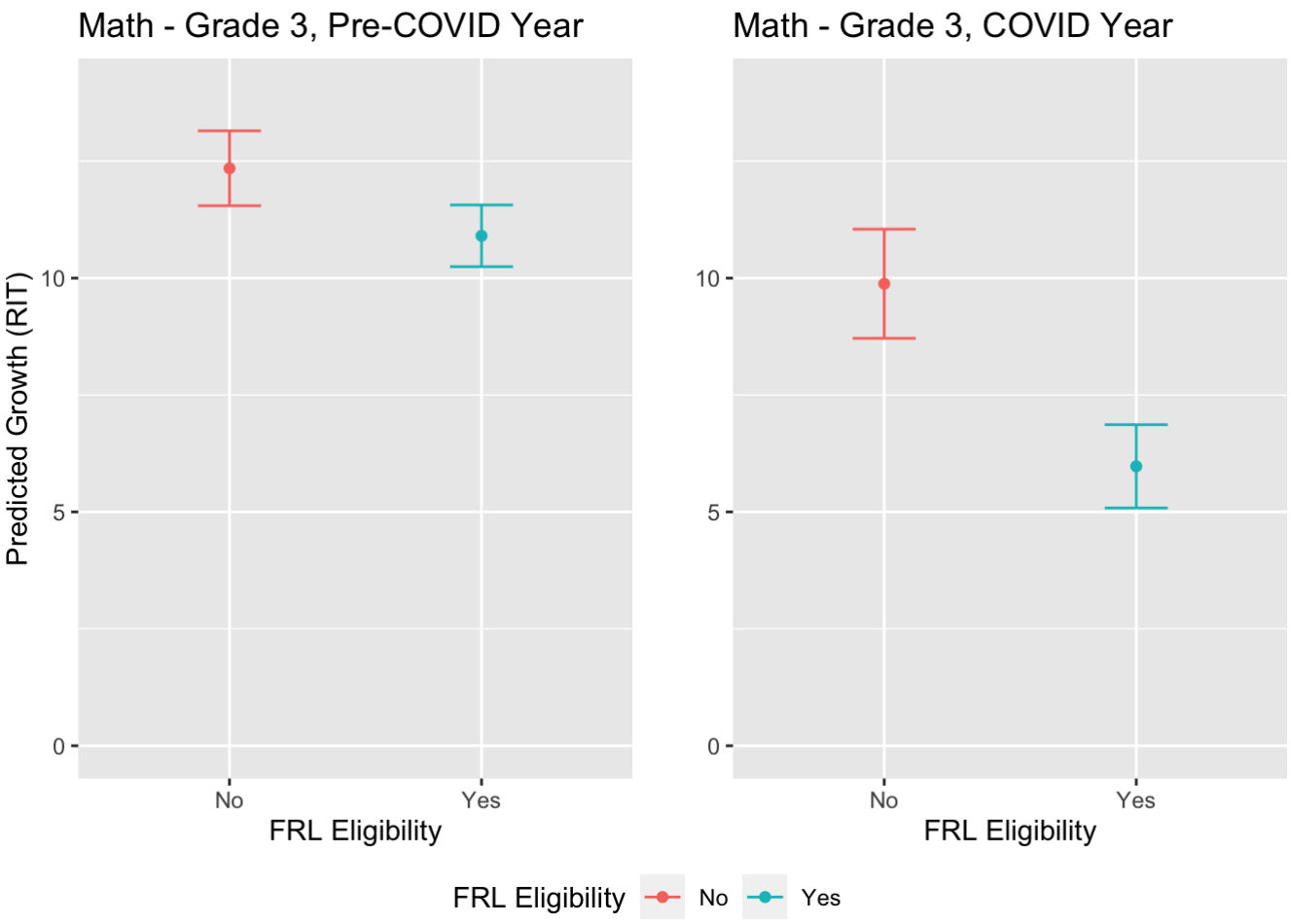
The dots on the charts represent the expected value (point estimate) in RIT terms. The error bars extending from the point represent the 95% confidence interval (CI) of each estimate. Larger bars indicate less precision which is often associated with smaller within group sample sizes. These 95% CIs are on the marginal effect which is the partial derivative of the above equation with respect the variable in question. Thus, non-overlapping CIs indicate strong compatibility with the hypothesis of a true difference between groups.

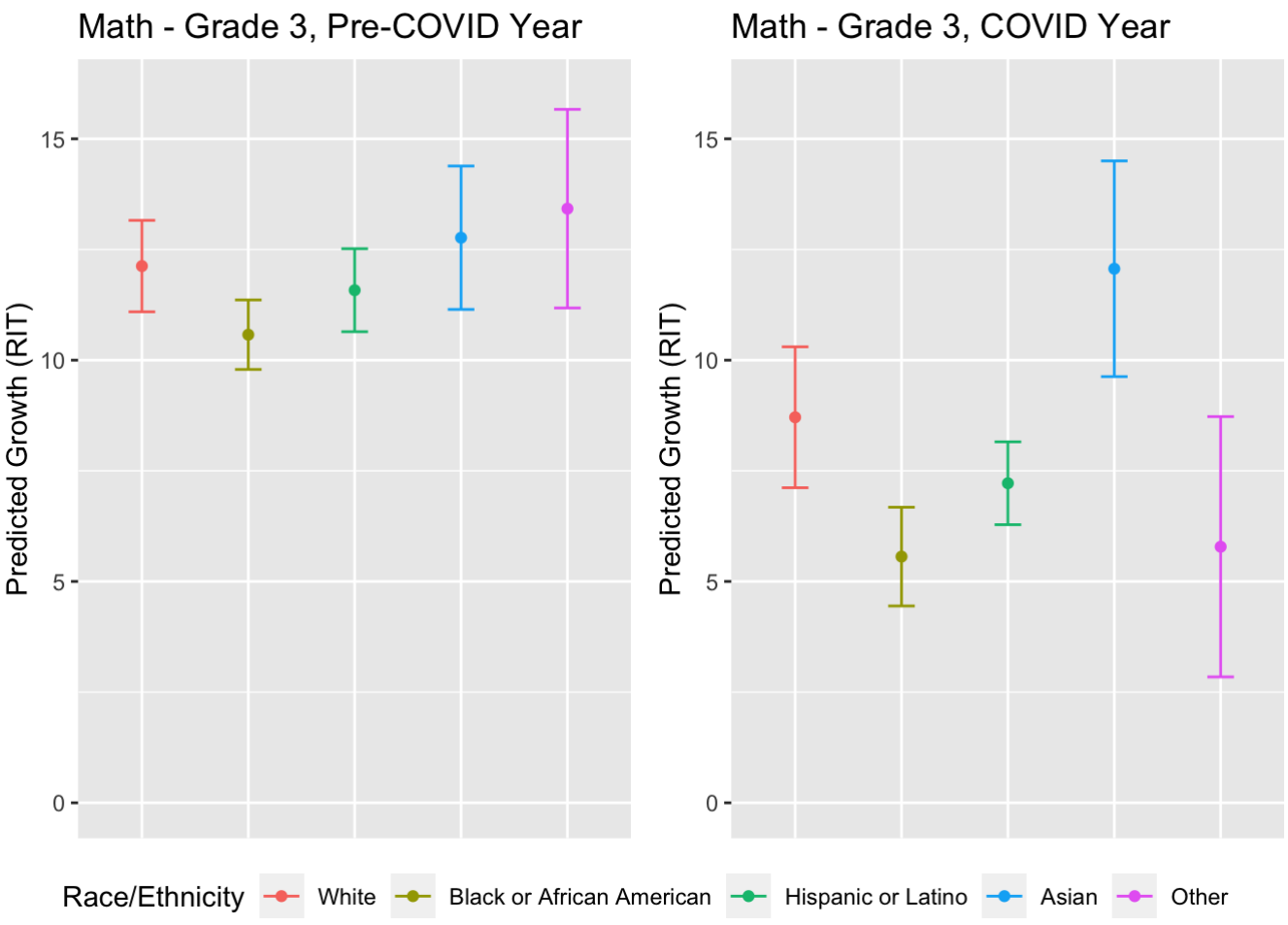
Examining the grade 3 estimates of FRL impact on mathematics growth, we see that expected growth for FRL eligible students is lower in both school years. Additionally, the expected growth of both FRL eligible and non-eligible students is lower in the COVID school year than their counterparts in the pre-COVID year. Both of these observations are inline with previous research. We note, however, that the gap between eligible students is larger in the COVID year suggesting that for grade 3 students, at least, COVID based learning loss was more significant for lower income students.

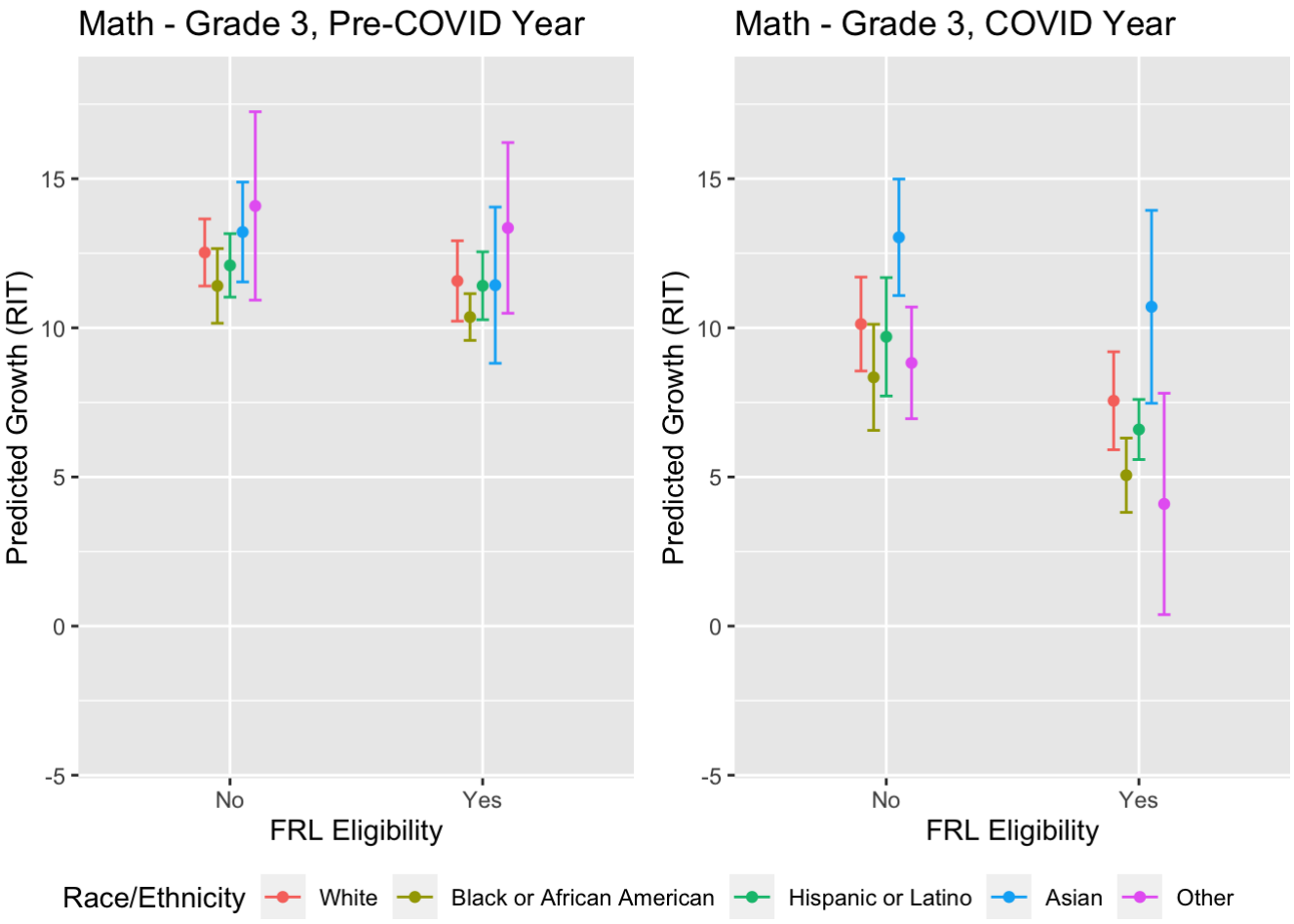
The next set of charts illustrate the marginal effect of race/ethnicity on grade 3 growth rates in mathematics. Again, we control for starting score in the starting fall term. However, we exclude FRL eligibility. In the pre-COVID year, estimates are closely grouped together. In the COVID year, students of color appear to be impacted to a greater extent than Asian students and somewhat more than White students.

The final model considers both sets of variables together along with their interactions. Again, in the pre-COVID year we see that across FRL eligibility and racial categories the expected growth with an average starting score are quite similar. However, in the COVID year expected growth has much more variability across FRL eligibility and across FRL within racial group. For instance, in the pre-COVID year Black, FRL eligible students have a point estimate that is close to the non-eligible, Black point estimate and within the 95% CI. In the COVID year, the point estimate for Black, FRL eligible students and it's associated CI is completely below the CI for non-eligible students. This indicates a statistically significant difference (at the 95% confidence level) in expected outcome.

This exploration of separate versus combined analyses is repeated for grades 4 and 5 below. The pattern remains similar. The point of examining each group separately before the combined analysis is to illustrate that overall averages may mask within group variation. It may not be possible to see, for instance, FRL eligibility has a larger impact on Black students than on White students unless we consider all of these variables at the same time. For the remainder of the study (Math - grades 6 and 7, Reading grades 3 through 7) we present only the combined analysis. Coefficient tables for the full models for all grades in both reading and mathematics are available in Appendix A.


Math - Grade 3, Pre-COVID Year
Math - Grade 3, COVID Year
Predicted Growth (RIT)
10
5
0
No
Yes
FRL Eligibility
FRL Eligibility
No
Yes


Math - Grade 3, Pre-COVID Year
Math - Grade 3, COVID Year
Predicted Growth (RIT)
15
10
5
0
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 3, Pre-COVID Year
Math - Grade 3, COVID Year
Predicted Growth (RIT)
15
10
5
0
-5
No
Yes
FRL Eligibility
Race/Ethnicity
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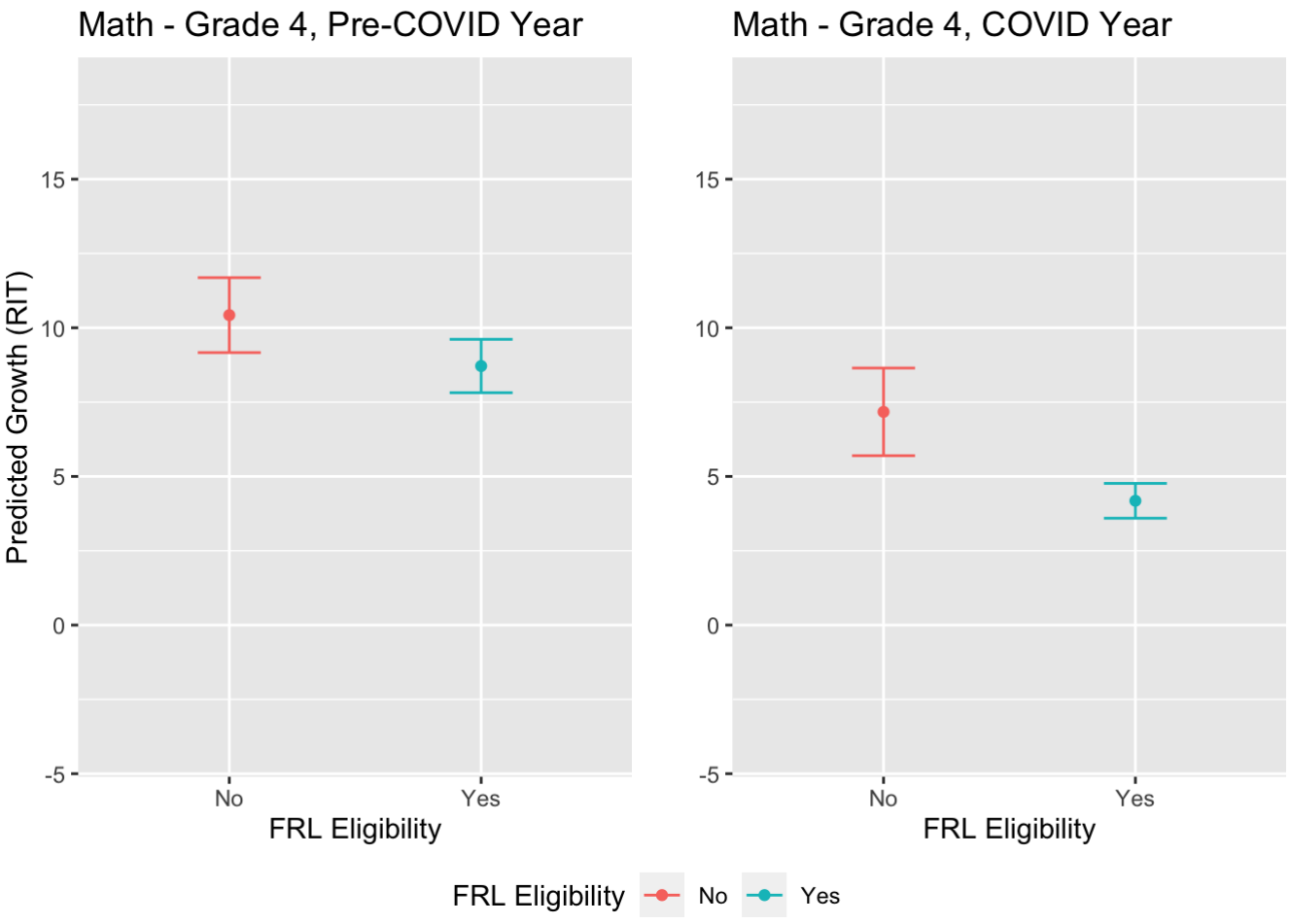
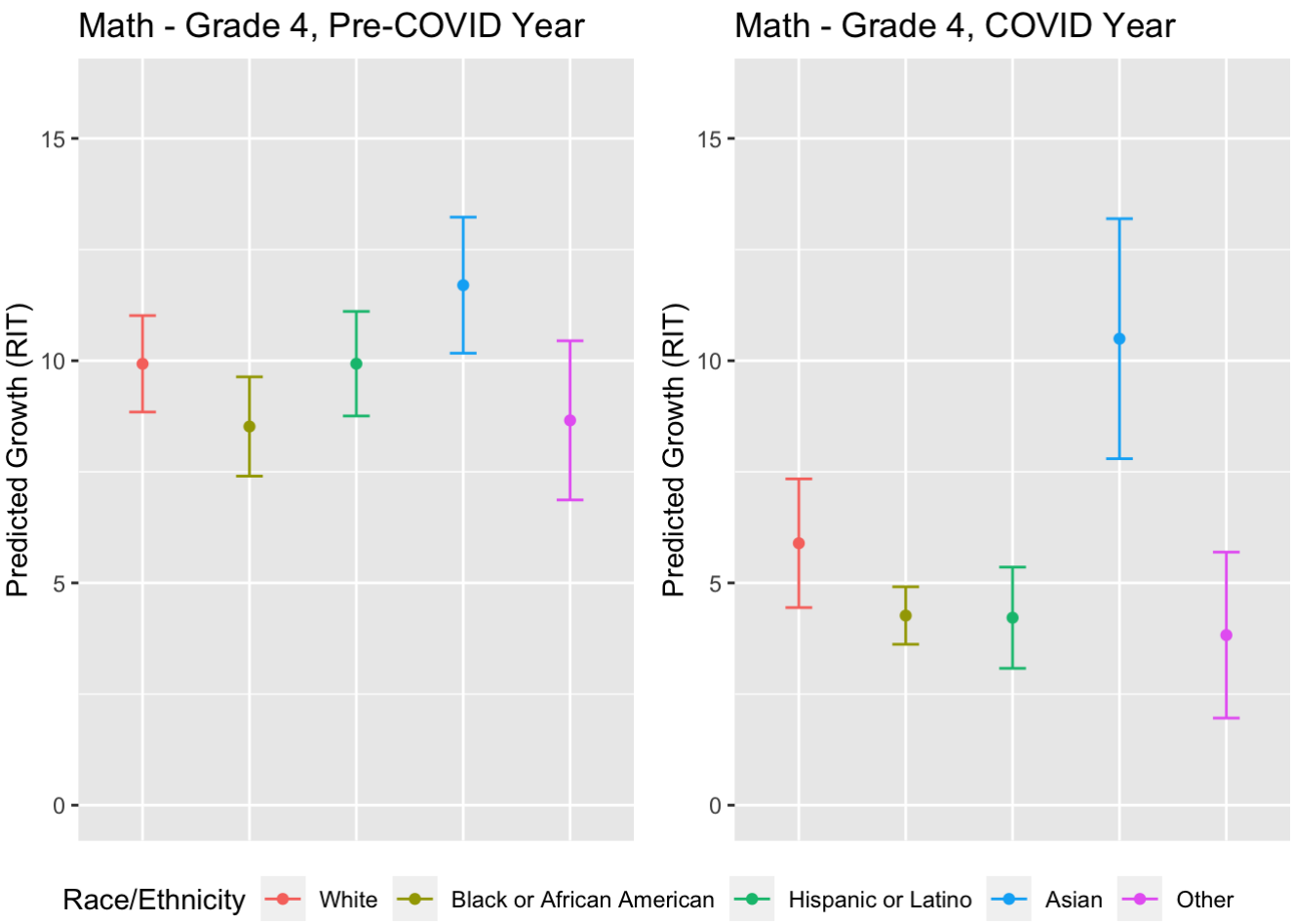
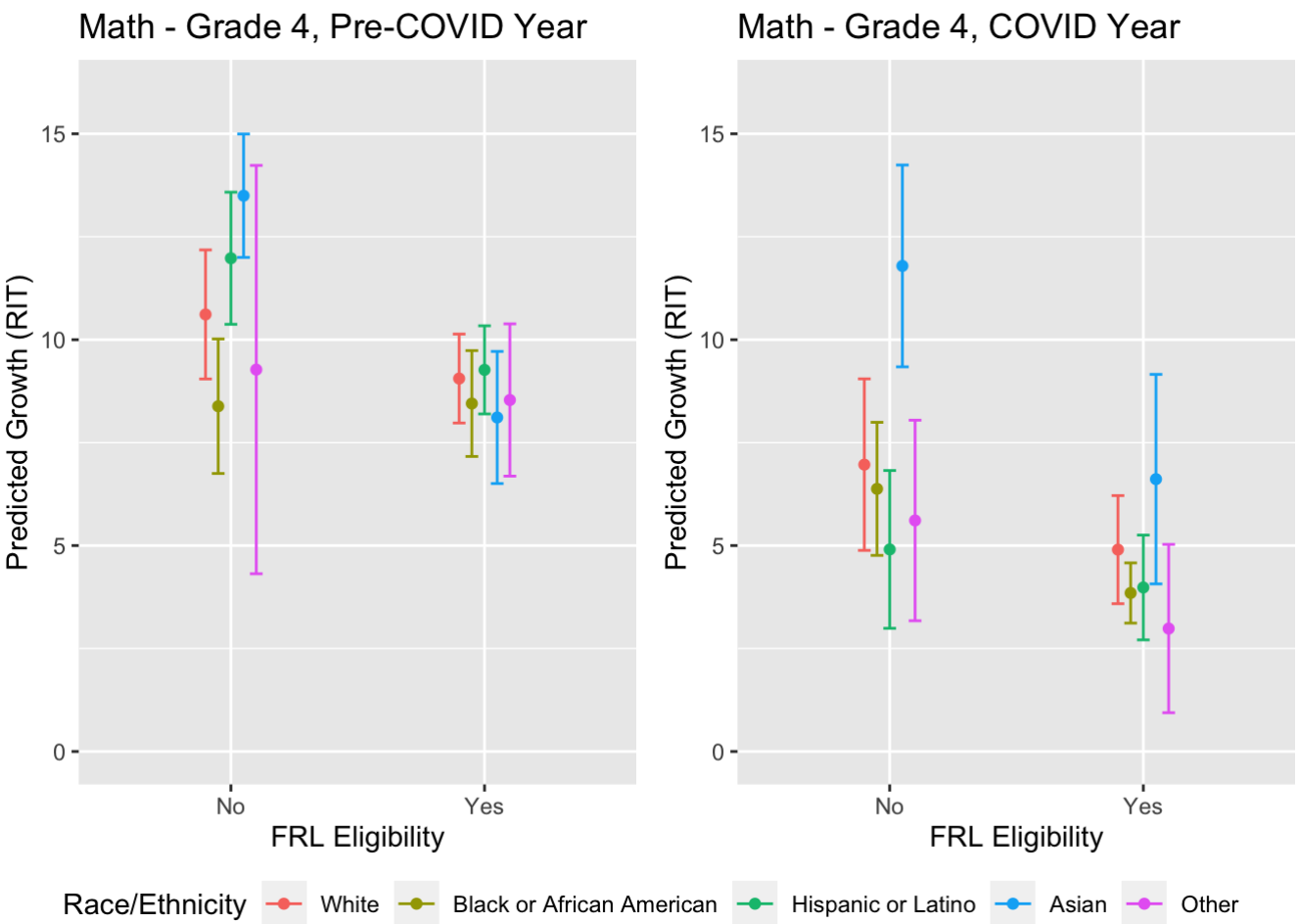
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 4, Pre-COVID Year
Math - Grade 4, COVID Year
Predicted Growth (RIT)
15
10
5
0
-5
No
Yes
FRL Eligibility
FRL Eligibility
No
Yes


Math - Grade 4, Pre-COVID Year
Math - Grade 4, COVID Year
Predicted Growth (RIT)
15
10
5
0
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 4, Pre-COVID Year
Math - Grade 4, COVID Year
Predicted Growth (RIT)
15
10
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FRL Eligibility
Race/Ethnicity
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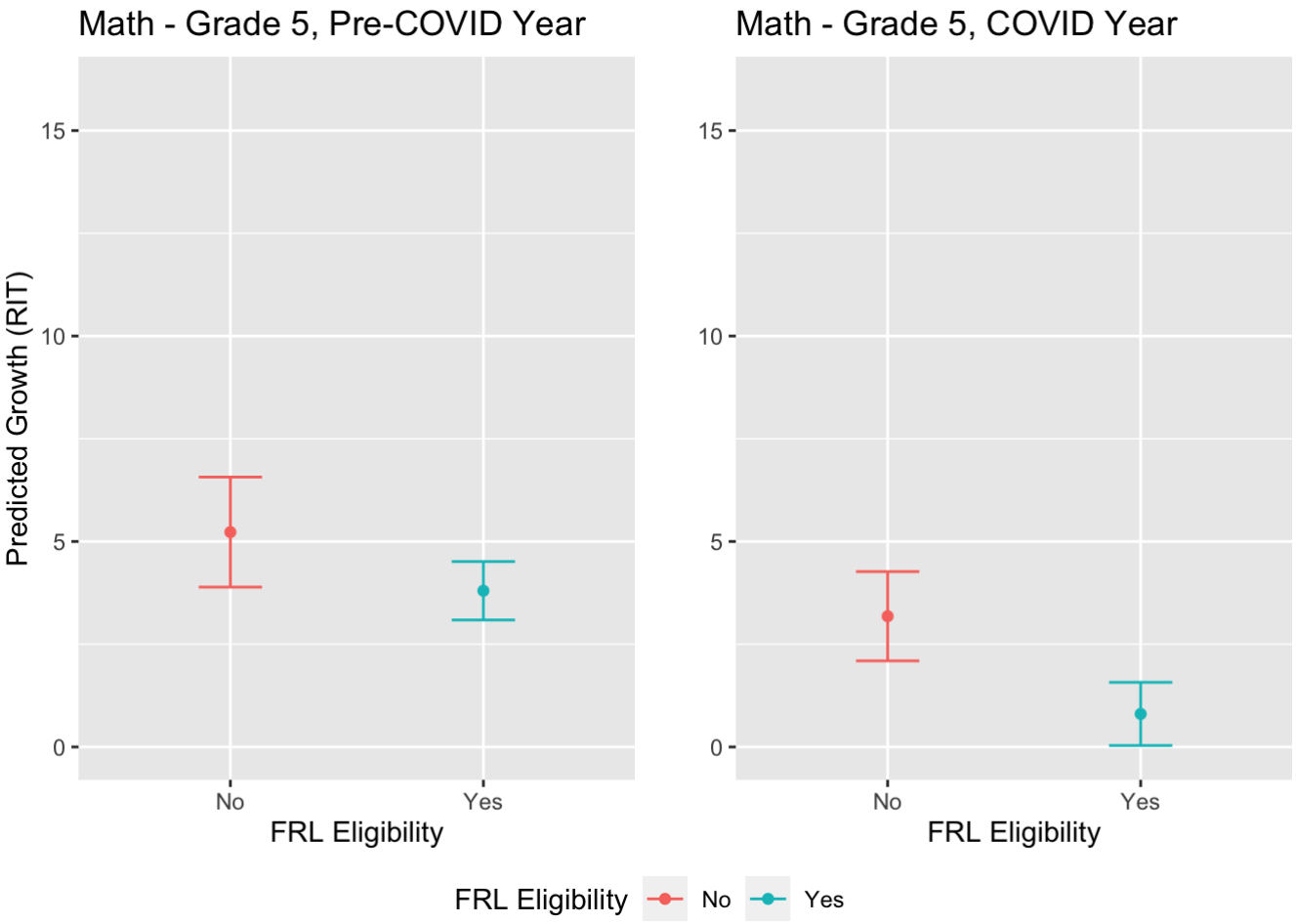
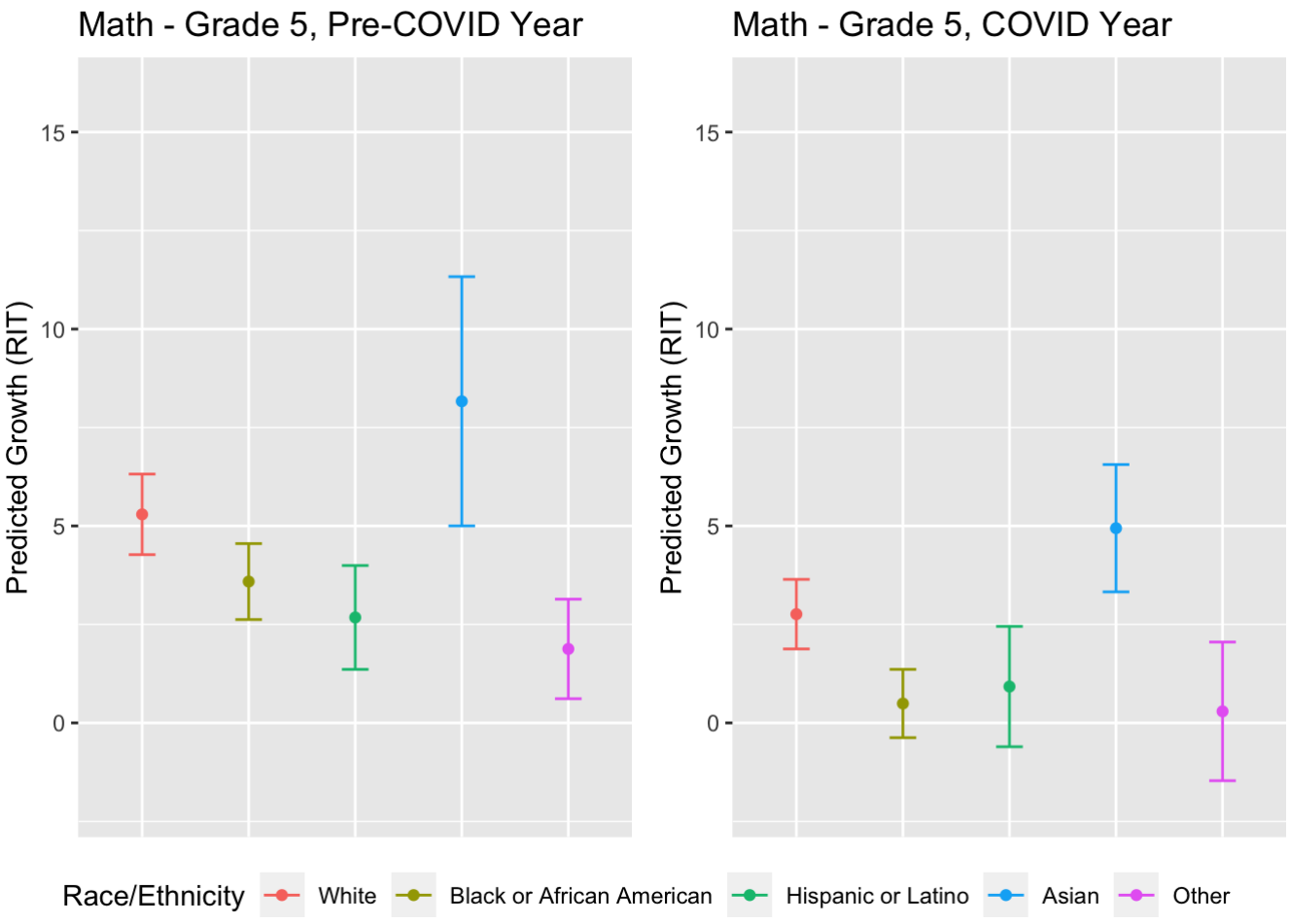
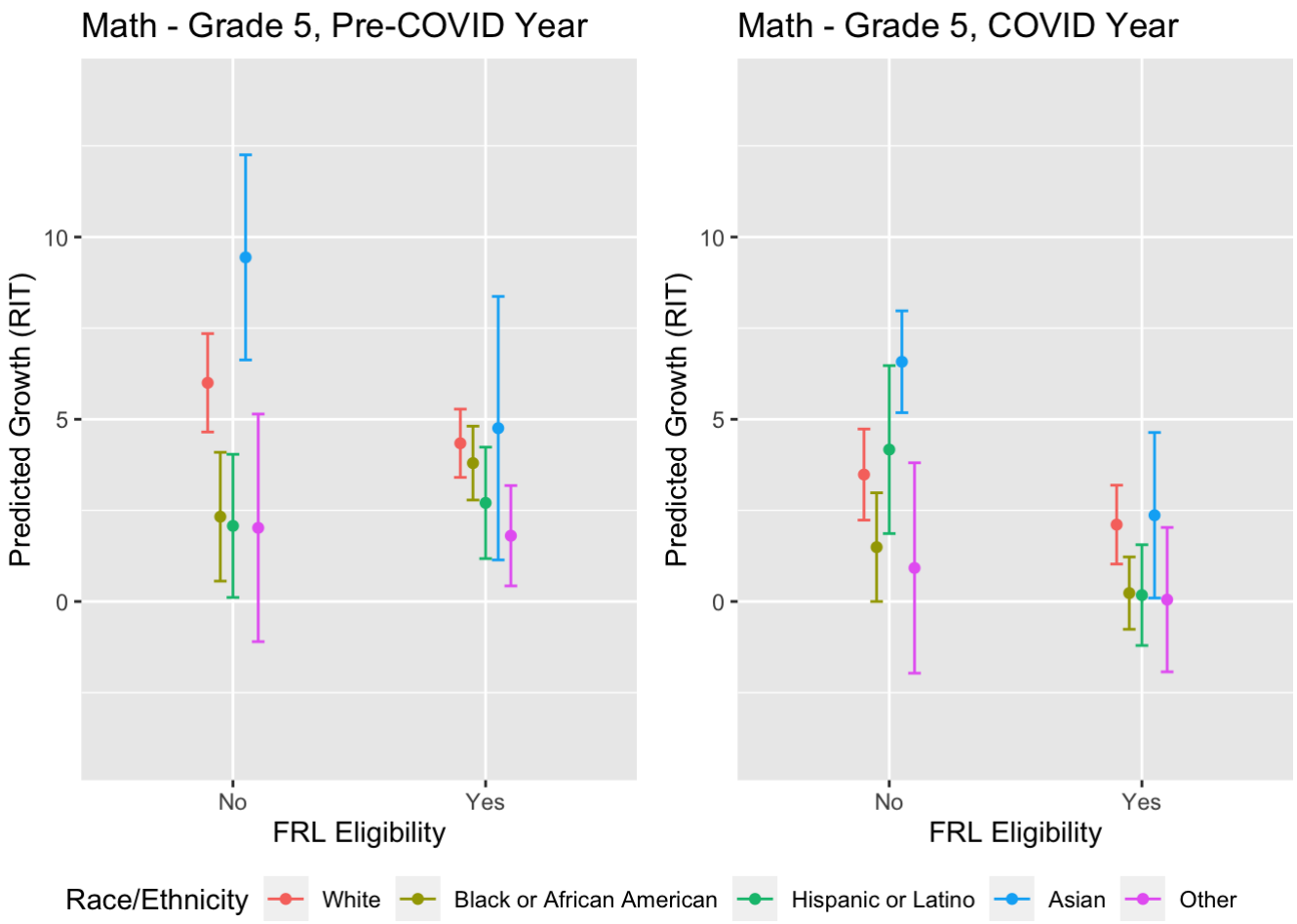
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 5, Pre-COVID Year
Math - Grade 5, COVID Year
Predicted Growth (RIT)
15
10
5
0
No
Yes
FRL Eligibility
FRL Eligibility
No
Yes


Math - Grade 5, Pre-COVID Year
Math - Grade 5, COVID Year
Predicted Growth (RIT)
15
10
5
0
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 5, Pre-COVID Year
Math - Grade 5, COVID Year
Predicted Growth (RIT)
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
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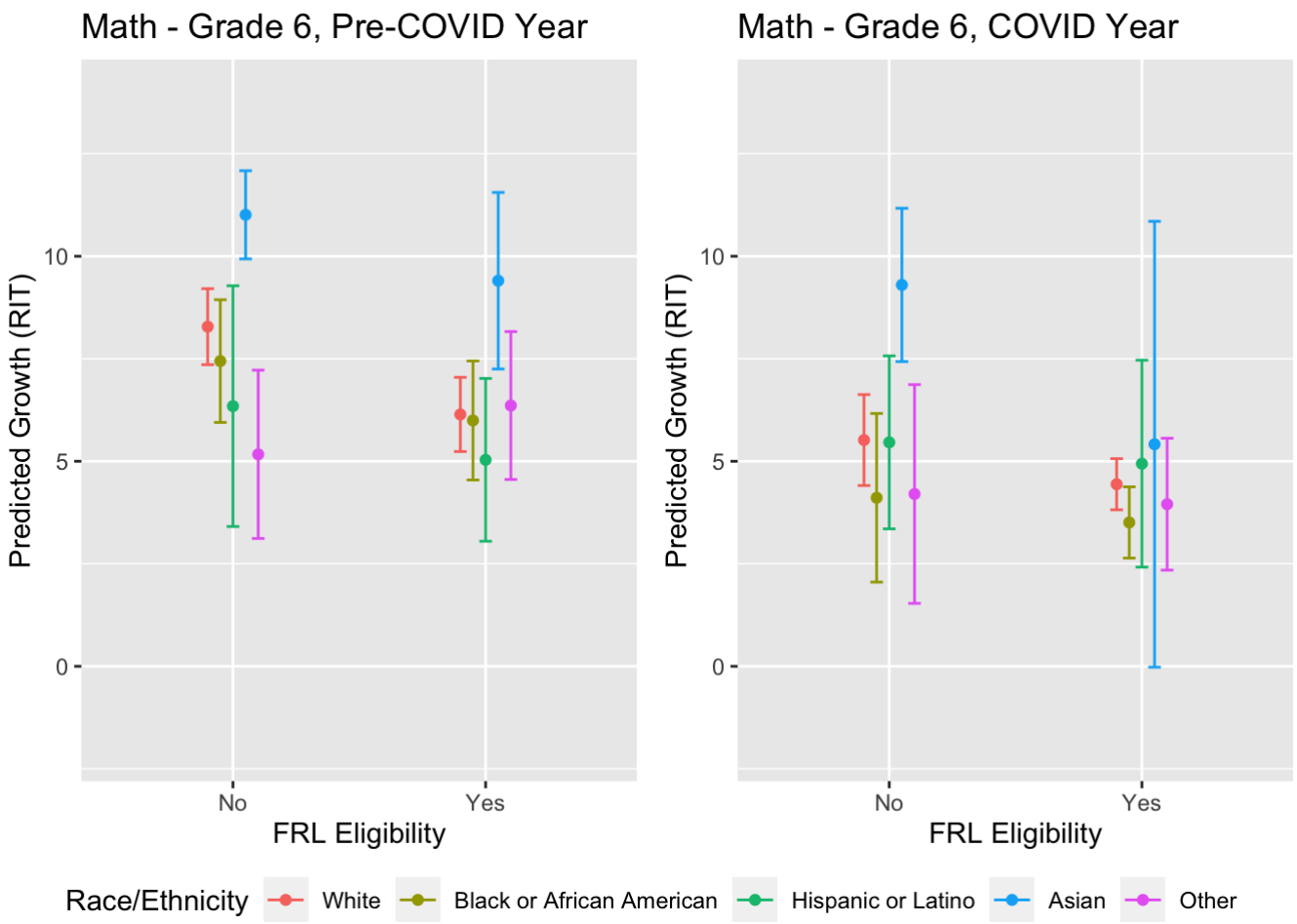
Black or African American
Hispanic or Latino
Asian
Other


Math - Grade 6, Pre-COVID Year
Math - Grade 6, COVID Year
Predicted Growth (RIT)
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
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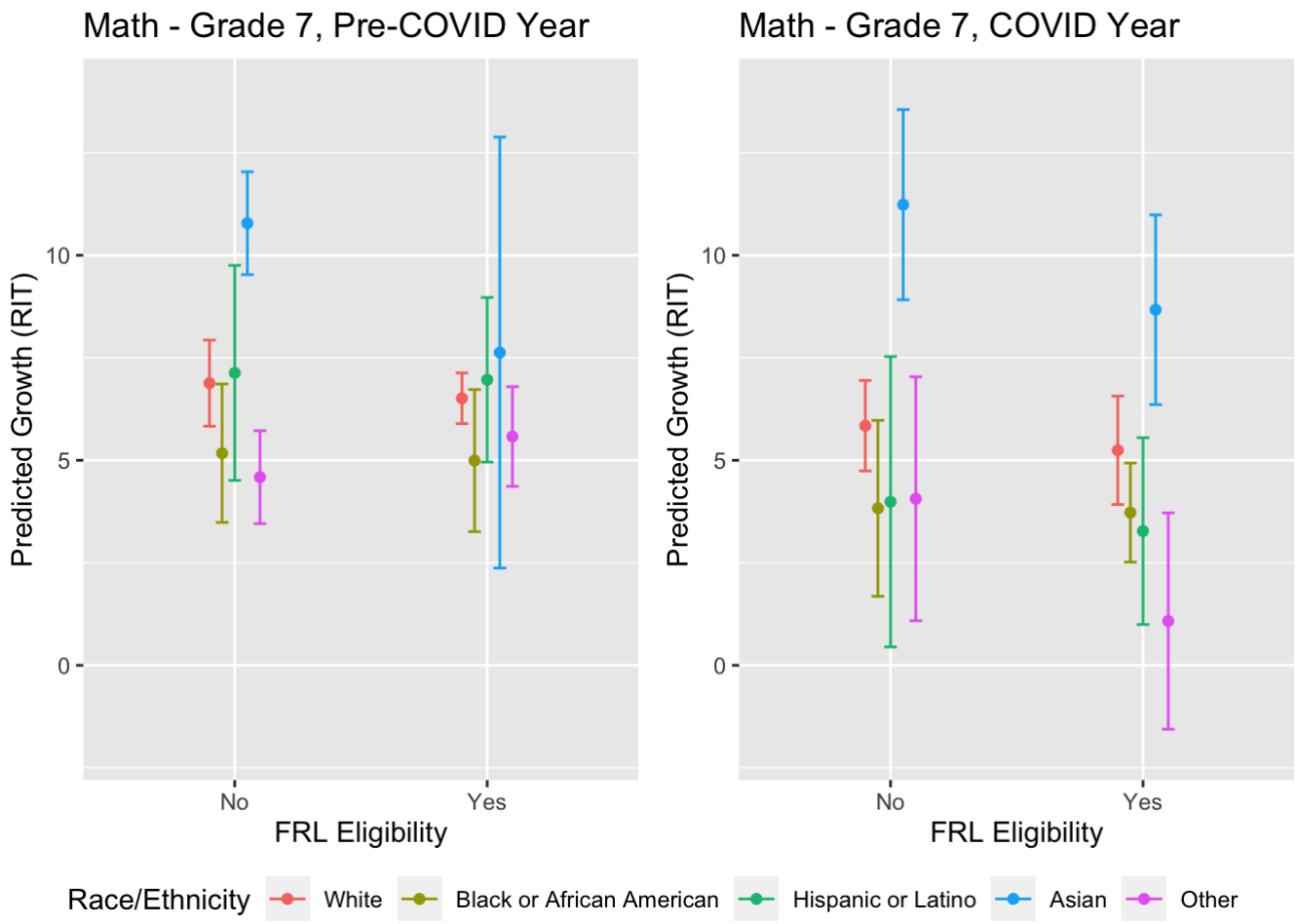
Black or African American
Hispanic or Latino
Asian
Other



Results for Mathematics

We can draw some important conclusions from the full models. Below we summarize the general trends in mathematics and then focus on specific examples that can be related to practical significance. The general trends are:

1. Overall growth is lower for nearly all demographic groups in each grade in the COVID year. Any deviations from this trend are estimated with a greater degree of uncertainty.
2. The variation between demographic groups is generally larger in the COVID year.
3. While the variation is larger in the COVID year, variation decreases as we progress through the grade levels.
4. Within students of color racial groups, there is evidence that FRL eligible students suffered larger learning losses than their peers.

This last point is critical. With respect to mathematics, the gap in academic growth between FRL eligible Black students and White students has increased. As an example, consider the worst case scenario, 3rd grade. The conditional growth norm for a student starting with an average RIT score is about 11.42 RIT points. In percentile terms this the 50th conditional growth percentile. For White and Black non-FRL students in the pre-COVID year, the expected growth calculated from our model is 12.53 and 11.41, respectively. That's about the 57th and 50th percentile. White and Black FRL students had an expected growth of 11.57 and 10.36 or the 51st and the 43rd percentile.

In the COVID year, each of these groups saw declines in growth. For White and Black non-FRL students the expected growth is calculated as 10.13 and 8.34, respectively. That's about the 41st and the 30th percentile. White and Black FRL students had an expected growth of 7.56 and 5.06 or the 20th and the approximately the 10th percentile. Significant losses were experienced by most 3rd grade students. However, the gap between White non-FRL students and Black FRL students (a typical bellwether comparison for education gaps) grew from 2.17 RIT points in the pre-COVID year to 5.07 RIT points in the COVID year. In percentile rank terms the gap increased from about 14 percentiles to well over 30. This is a significant increase in the achievement gap.

At the other end of the spectrum, let's consider 7th grade. The White, non-FRL to Black, FRL achievement gap is 1.71 RIT points in the pre-COVID year. For reference, the normative growth in 7th grade is 6.01. In the COVID year, this same gap grew to 2.12 RIT points.

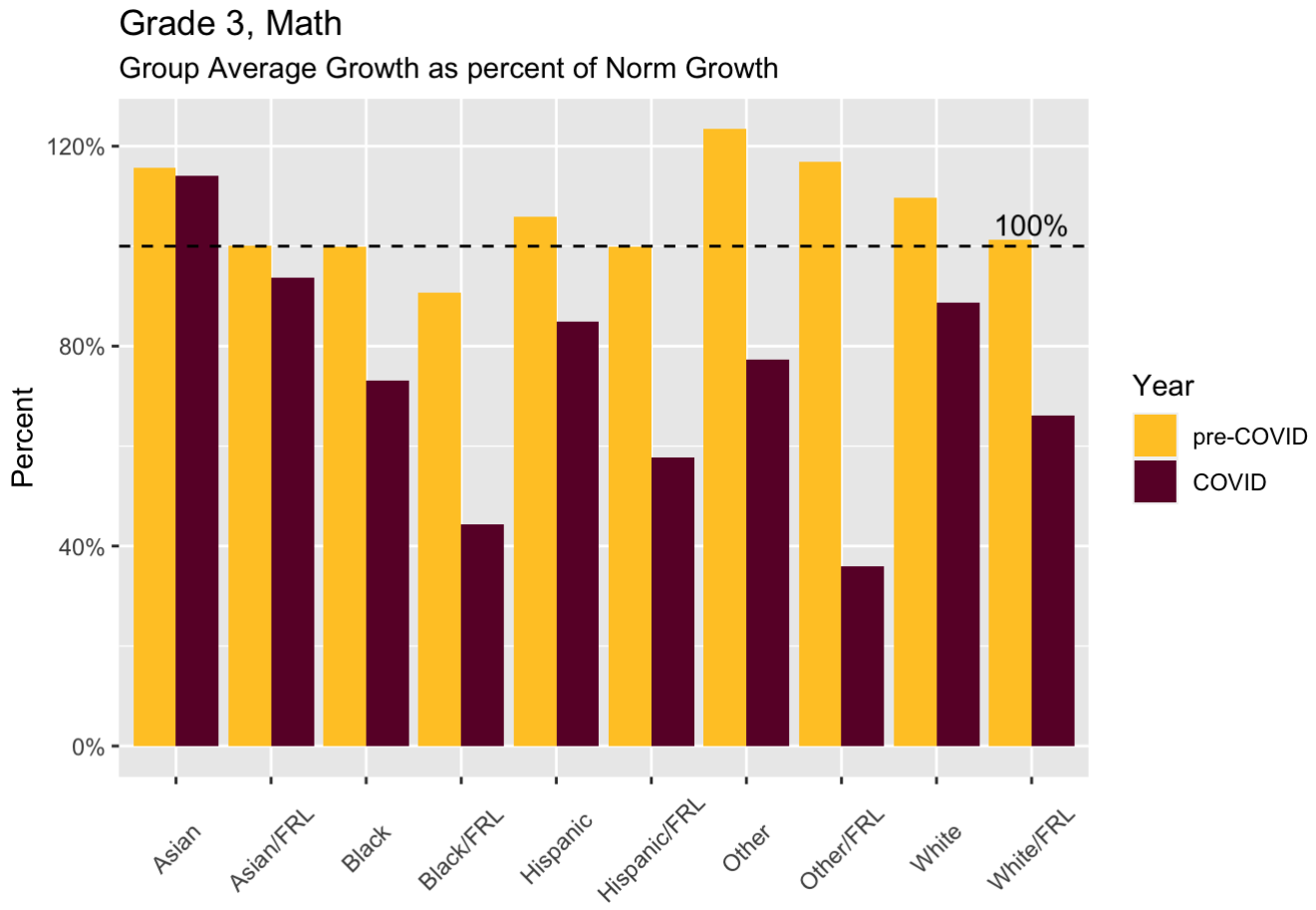
At first glance this might suggest that the gap in 7th grade didn't increase as much as in 3rd grade. However, we must consider what is typical growth in each grade. The next set of charts helps illustrate how growth between groups changed in the COVID impacted school year. Appendix B contains tables for each grade in both mathematics and reading which provide both the group average gap between each demographic group and the reference group (White, non-FRL) and between each group and the normative growth benchmark.

Each chart provides a grade level summary of pre-COVID and COVID year growth. The bars represent the group level average growth as a percent of normative growth for that grade level and subject. A bar above 100% means that the group average growth was higher than normative growth. A bar below 100% represents group average growth that was less than normative growth.

This approach allows us to compare changes in growth between groups on the basis of typical growth within grade level. Let's return to our comparison of Black/FRL to White non-FRL students in both 3rd grade and 7th grade. In 3rd grade during the COVID year, White non-FRL students achieved about 90% of normative growth, on average. Black/FRL students achieved less than 50% of normative growth, on average. For 7th grade, the comparison is very similar. White non-FRL students achieved a little over 90% of normative growth, on average. Black/FRL students achieved about 60% of normative growth, on average. Compared to the the pre-COVID year this gap is fairly similar. It does appear that demographic gaps increased in the lower grade levels in mathematics more than they did in the higher grade levels.

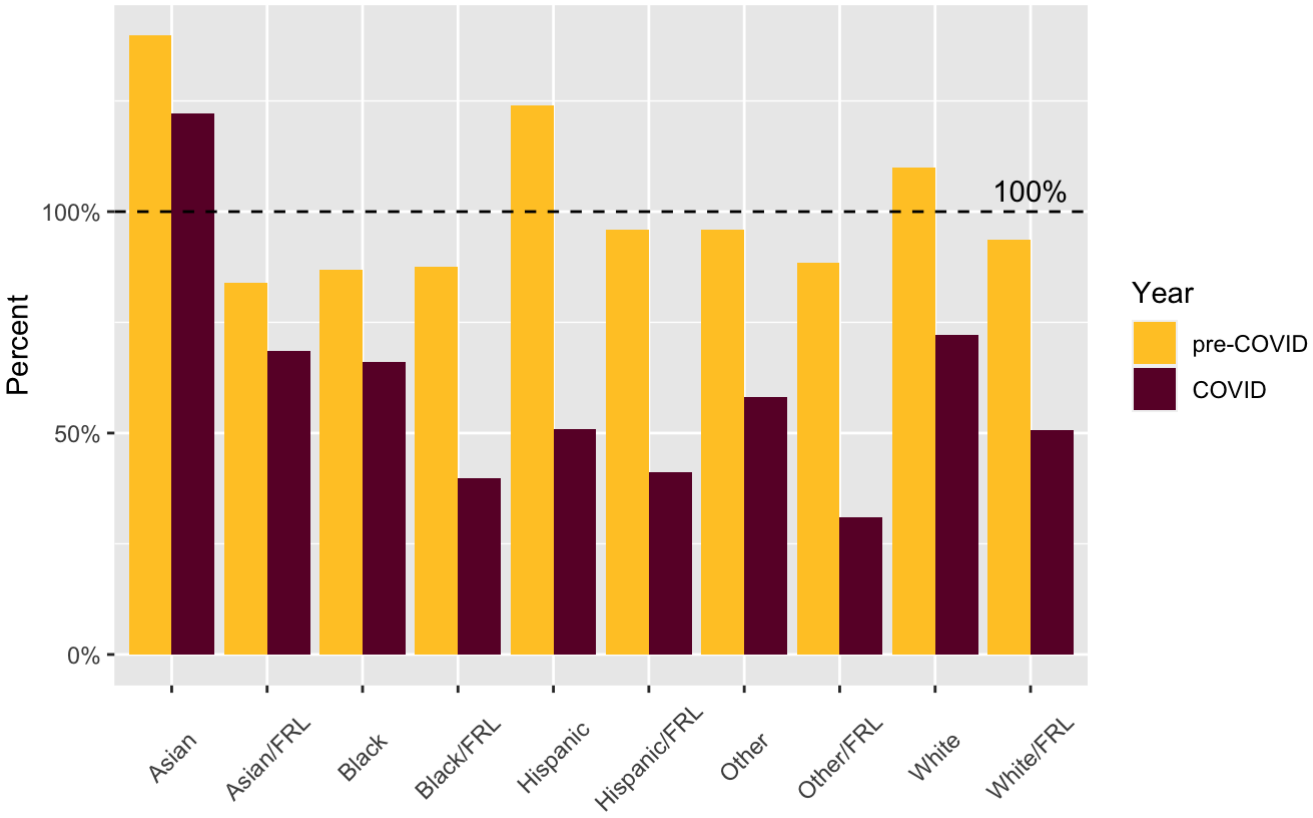
Previous research has indicated that achievement gaps between demographic groups typically persist as students advance through grade levels (Kuhfeld, Condron, and Downey provide a well thought out review of the literature). A one time shock at the lower grade levels may result in larger future gaps unless intervention is made. To the point of intervention, we contend that these findings provide implicit support for the idea that education in the formal schooling environment is critical to closing historic achievement gaps. In pre-COVID years gaps exist but they are certainly smaller than today. "Opportunity to Learn" researchers have long contended that access to educational opportunities are critical to closing these gaps (Schmidt et al., 2015; Schmidt et al. 2021). For our most vulnerable students these opportunities happen within our schools. The loss of school-based learning time has hurt all students in mathematics but evidence from this study suggests that the impact has been more significant for lower-income minority students.

Math - Gaps as percent of normative growth



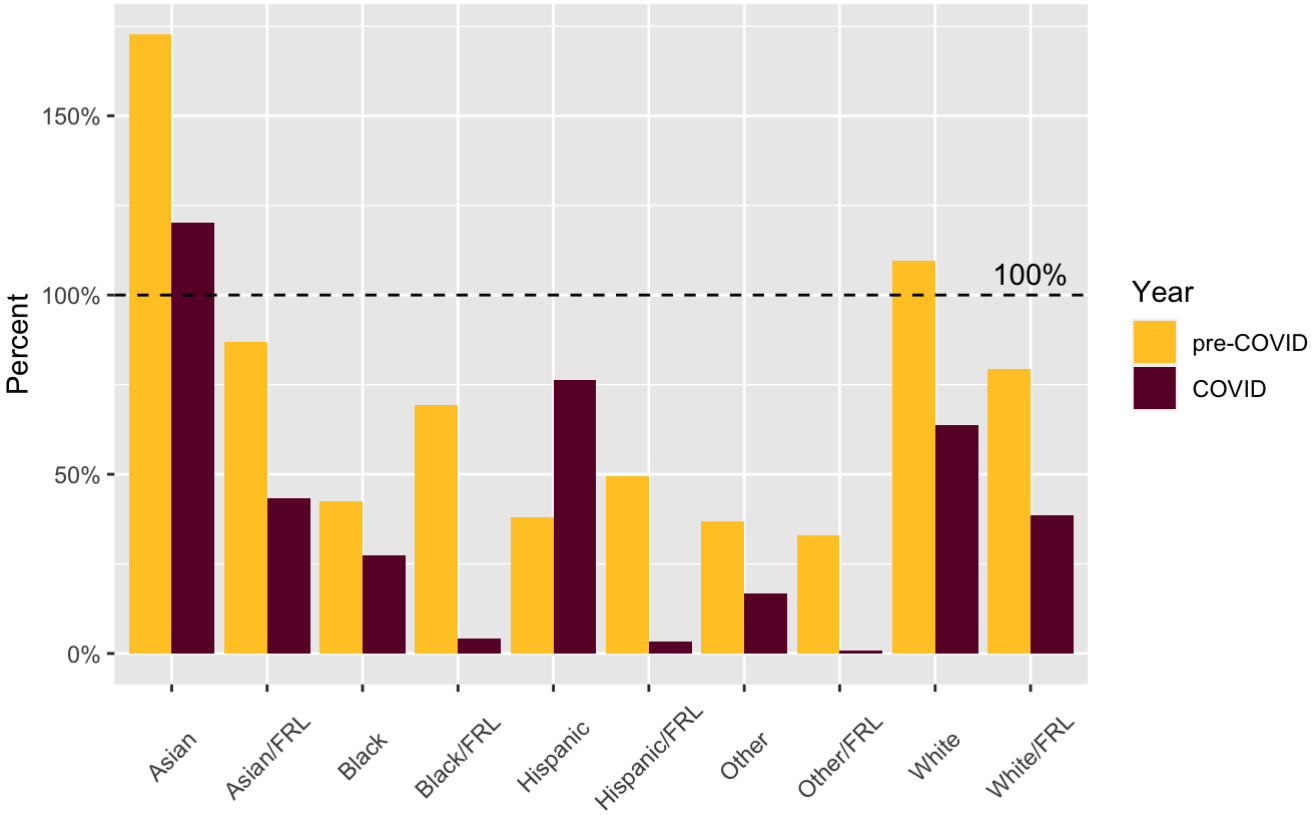
Grade 4, Math

Group Average Growth as percent of Norm Growth



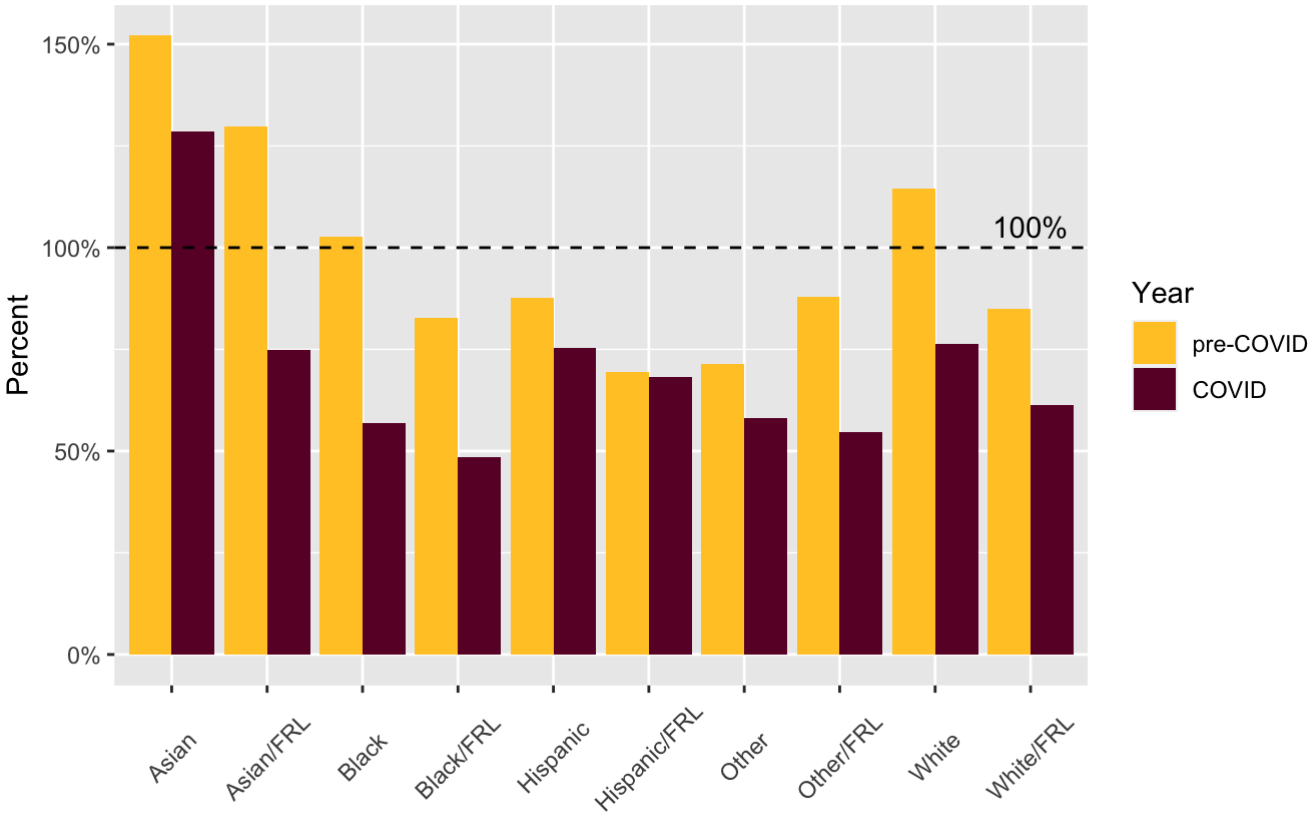
Grade 5, Math

Group Average Growth as percent of Norm Growth



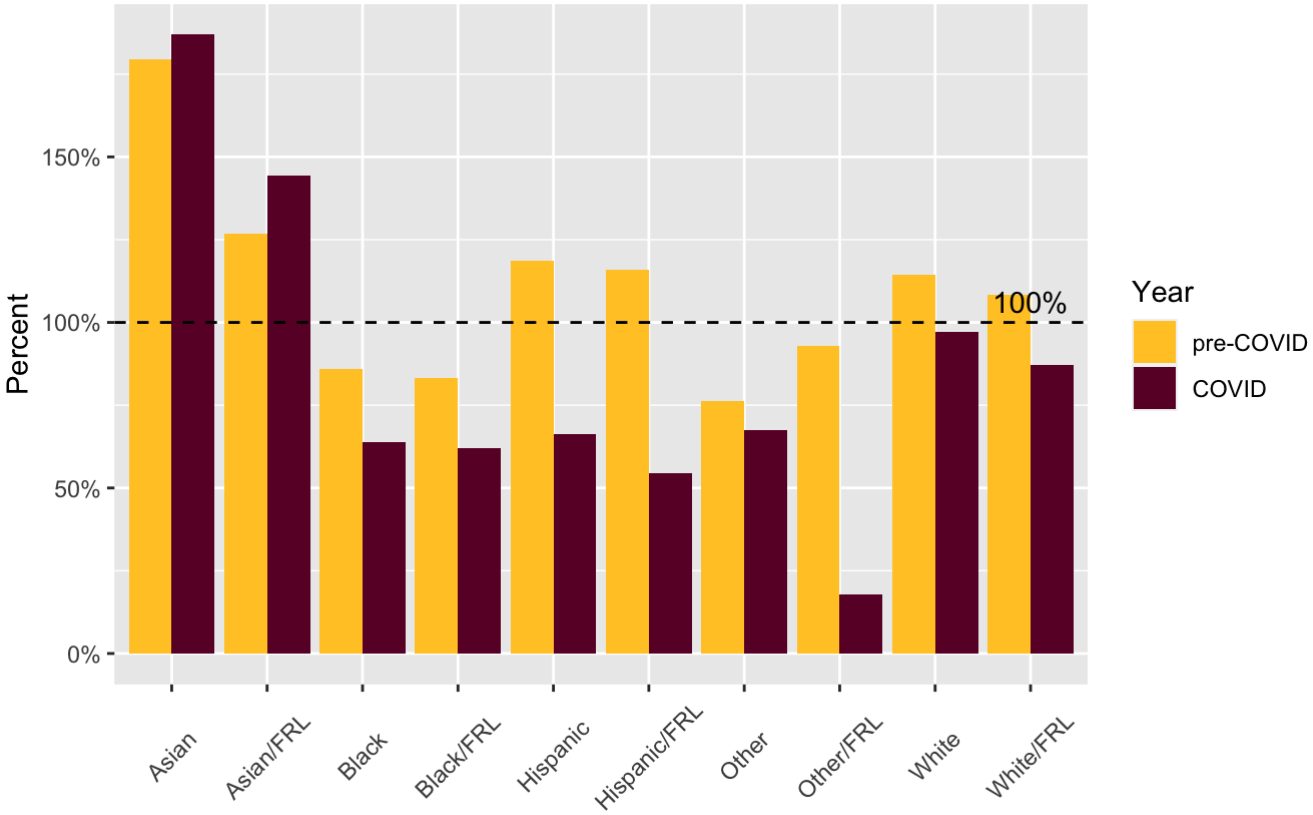
Grade 6, Math

Group Average Growth as percent of Norm Growth



Grade 7, Math

Group Average Growth as percent of Norm Growth

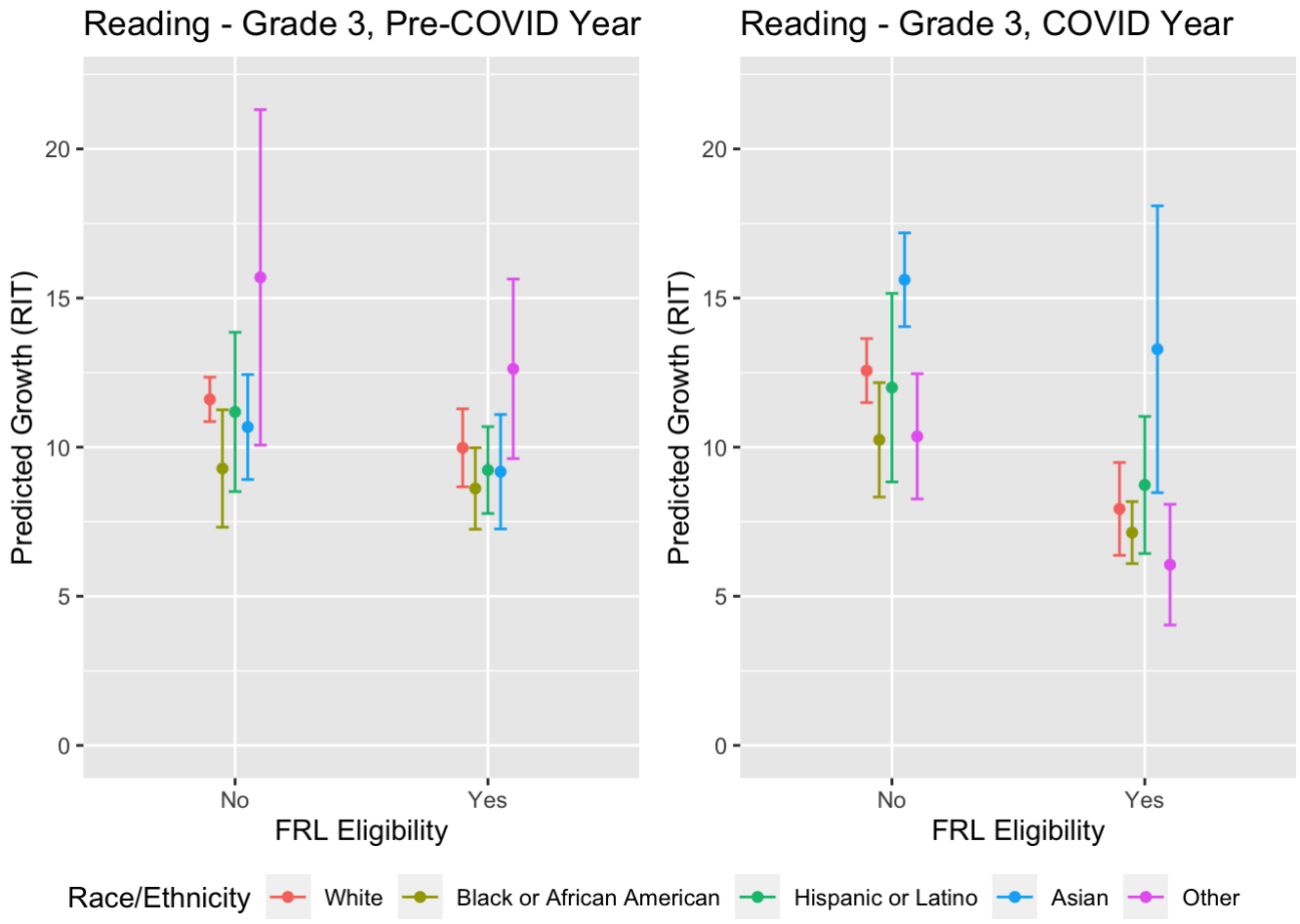


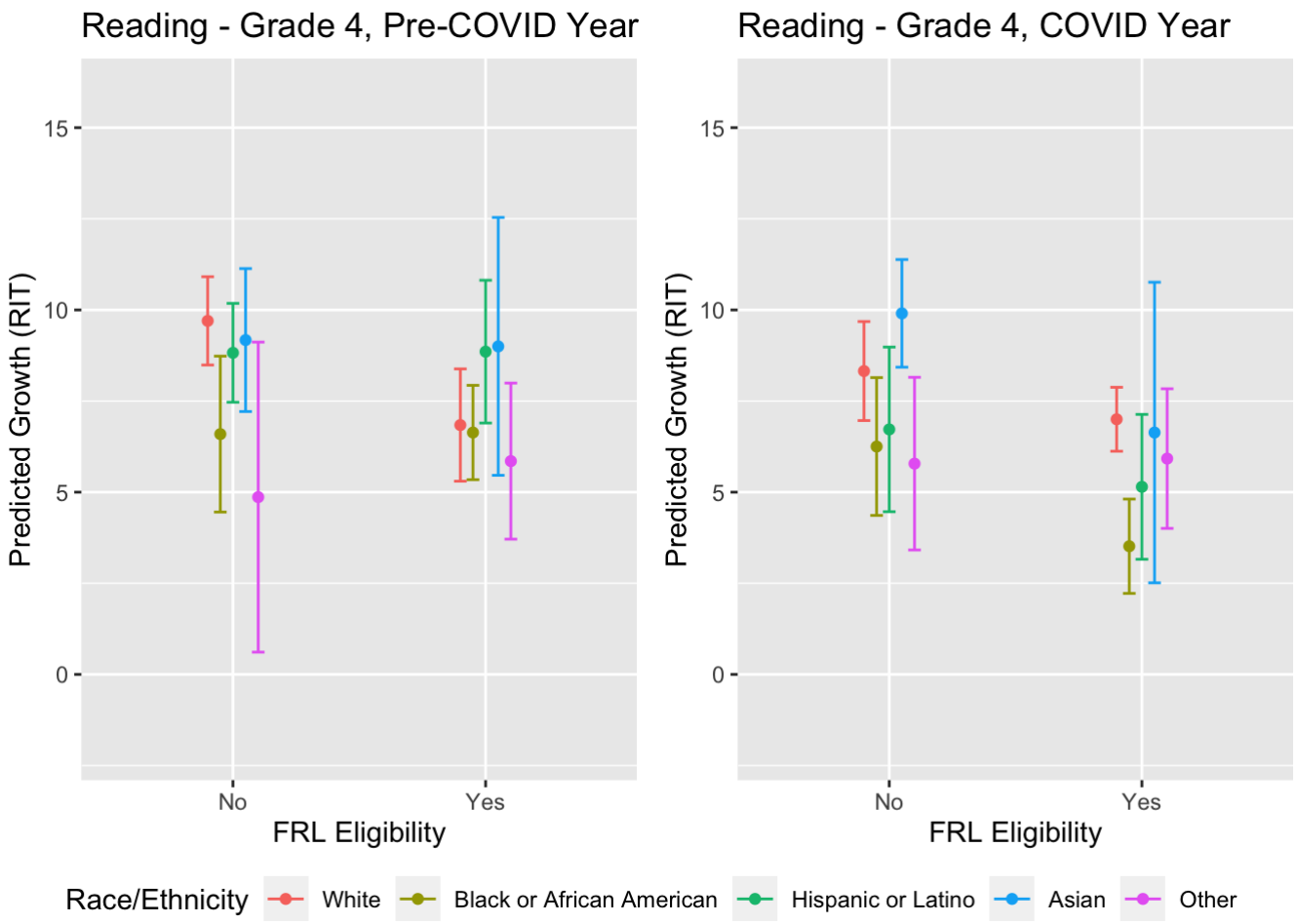
Reading Results

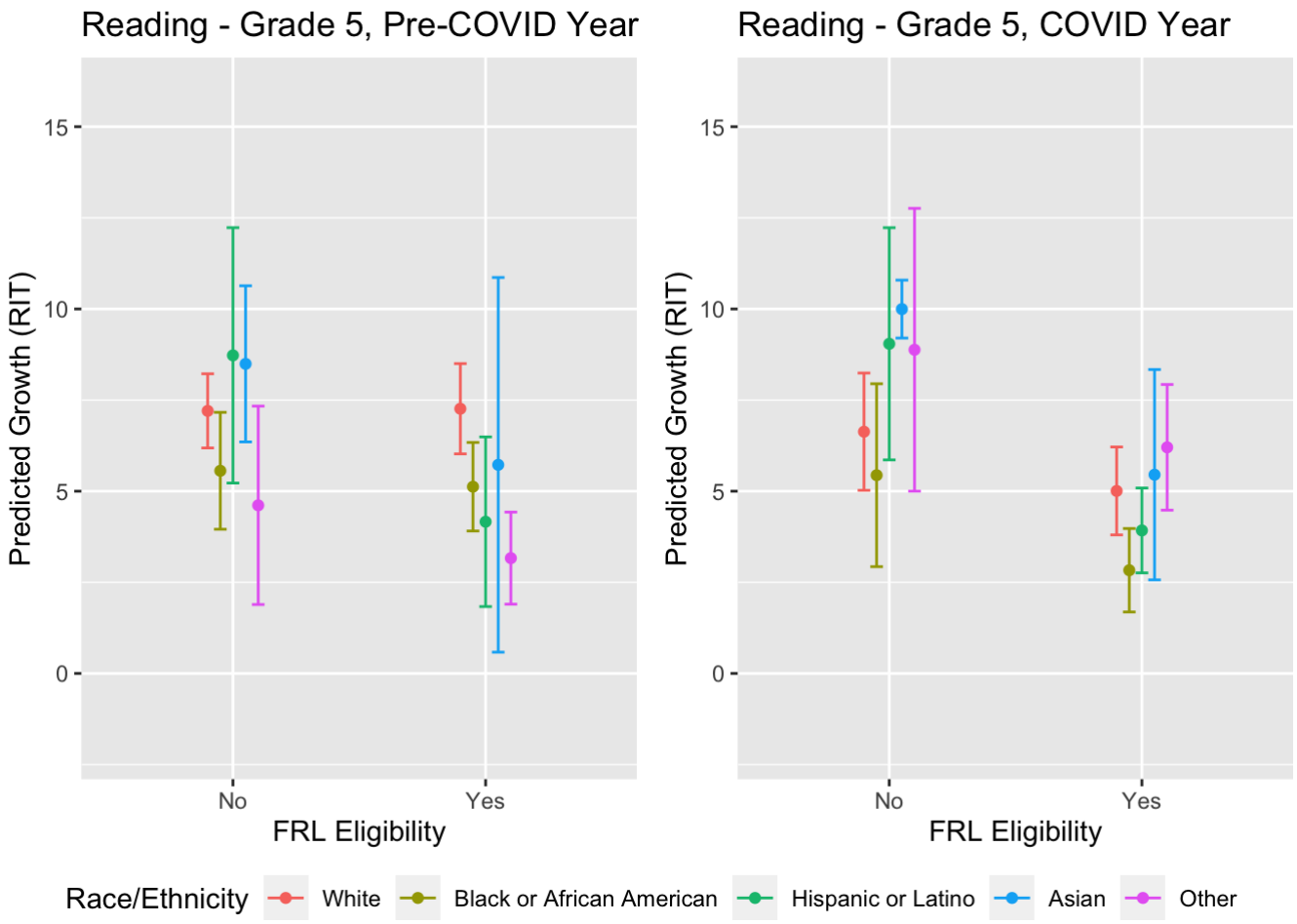
Research early in the fall of 2020 indicated that, on average, reading scores were inline with typical expectations for a new school year. There was considerable relief among educators and parents. As with the mathematics results we now take a closer look at achievement gaps between demographic groups.

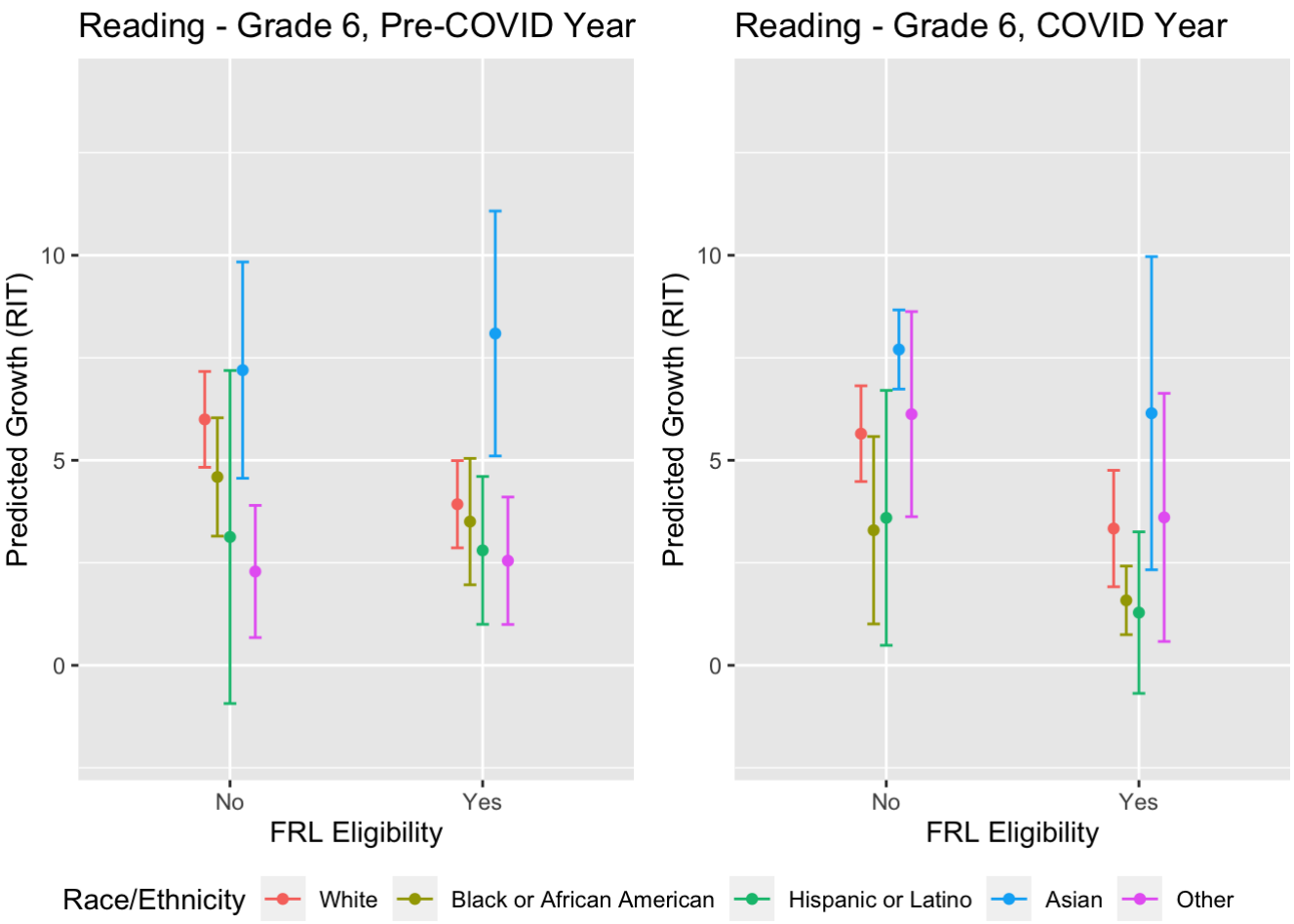
In 3rd grade, there is a widening of the gap between FRL and non-FRL students across racial groups. The gap is 1.96 RIT points in the pre-COVID year to 4.68 in the COVID year. However, this appears to be uniform across racial groups. Like mathematics, this trend appears to dissipate somewhat as we progress through grade levels. Thus, reading growth gaps between higher and lower socioeconomic status students did widen due to COVID but those gaps do not appear to differ systematically by racial group.

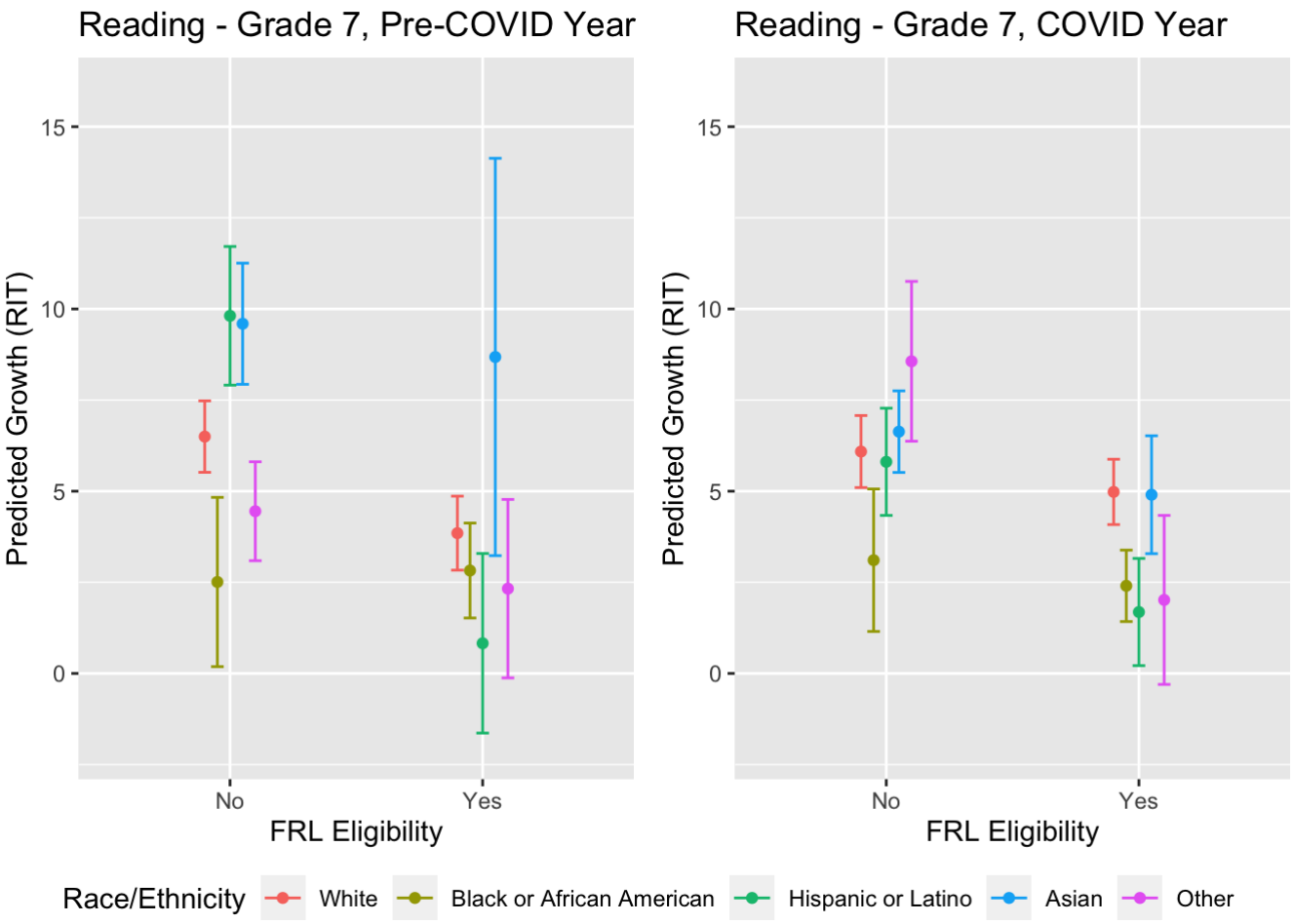
There is one important exception. Our bellwether comparison for inequality in education is Black/FRL students vs. White non-FRL students. We turn to our bar charts to compare gaps as a percent of normative growth in the next section to explore this relationship.




Reading - Grade 4, Pre-COVID Year
Reading - Grade 4, COVID Year
Predicted Growth (RIT)
15
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other


Reading - Grade 5, Pre-COVID Year
Reading - Grade 5, COVID Year
Predicted Growth (RIT)
15
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other

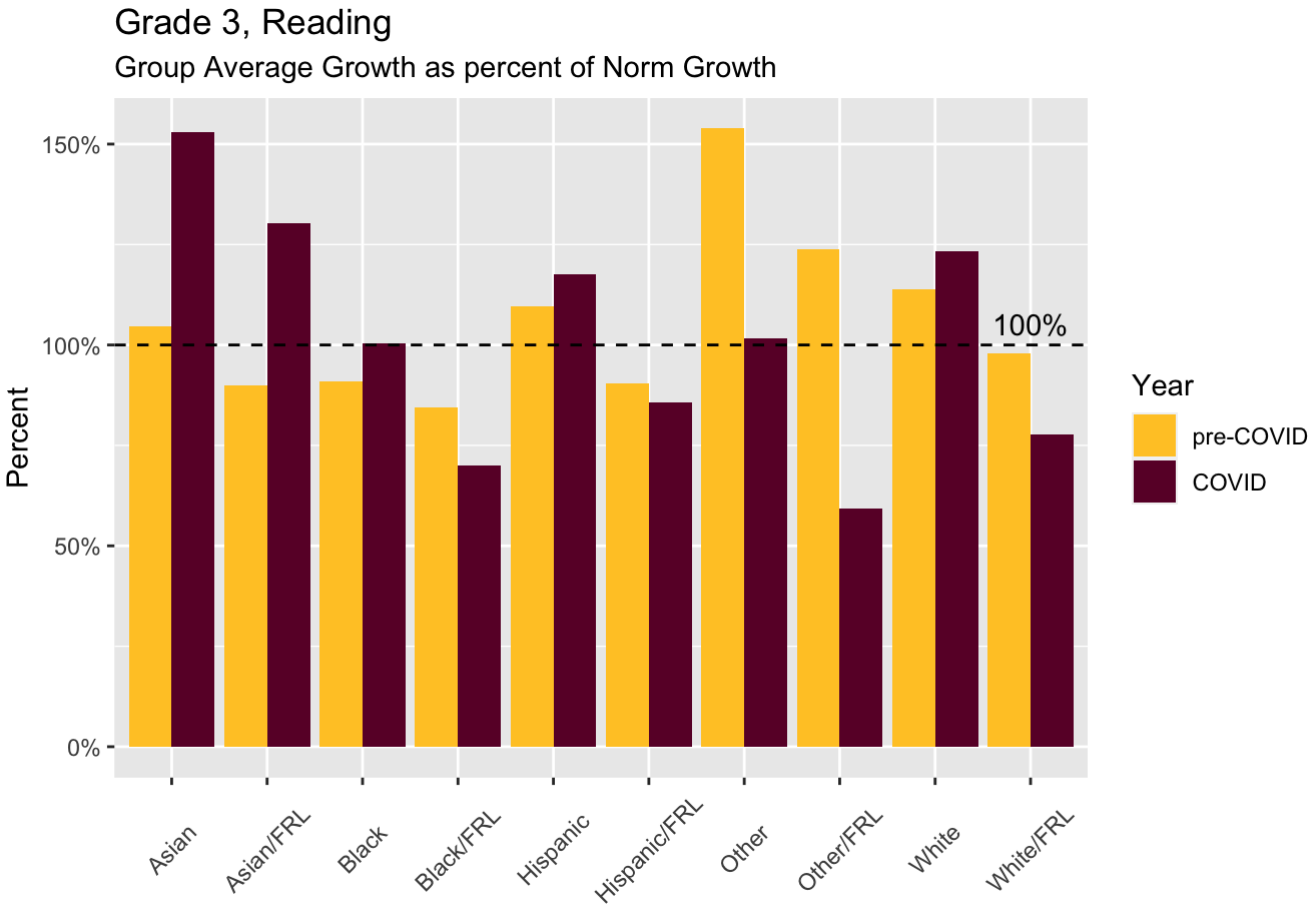

Reading - Grade 6, Pre-COVID Year
Reading - Grade 6, COVID Year
Predicted Growth (RIT)
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other


Reading - Grade 7, Pre-COVID Year
Reading - Grade 7, COVID Year
Predicted Growth (RIT)
15
10
5
0
No
Yes
FRL Eligibility
Race/Ethnicity
White
Black or African American
Hispanic or Latino
Asian
Other

While average reading growth between the pre-COVID and the COVID year are similar, there are important differences that are difficult to see until we place our comparison on a well thought out scale. Note that from grade 3 to grade 7 White, non-FRL students performed very similar in the pre-COVID year vs. the COVID year. Black/FRL students, however, consistently performed worse in the COVID year with the exception of 7th grade. However, while many groups actually saw increases in the COVID year, Black/FRL students see a decline in every grade level.

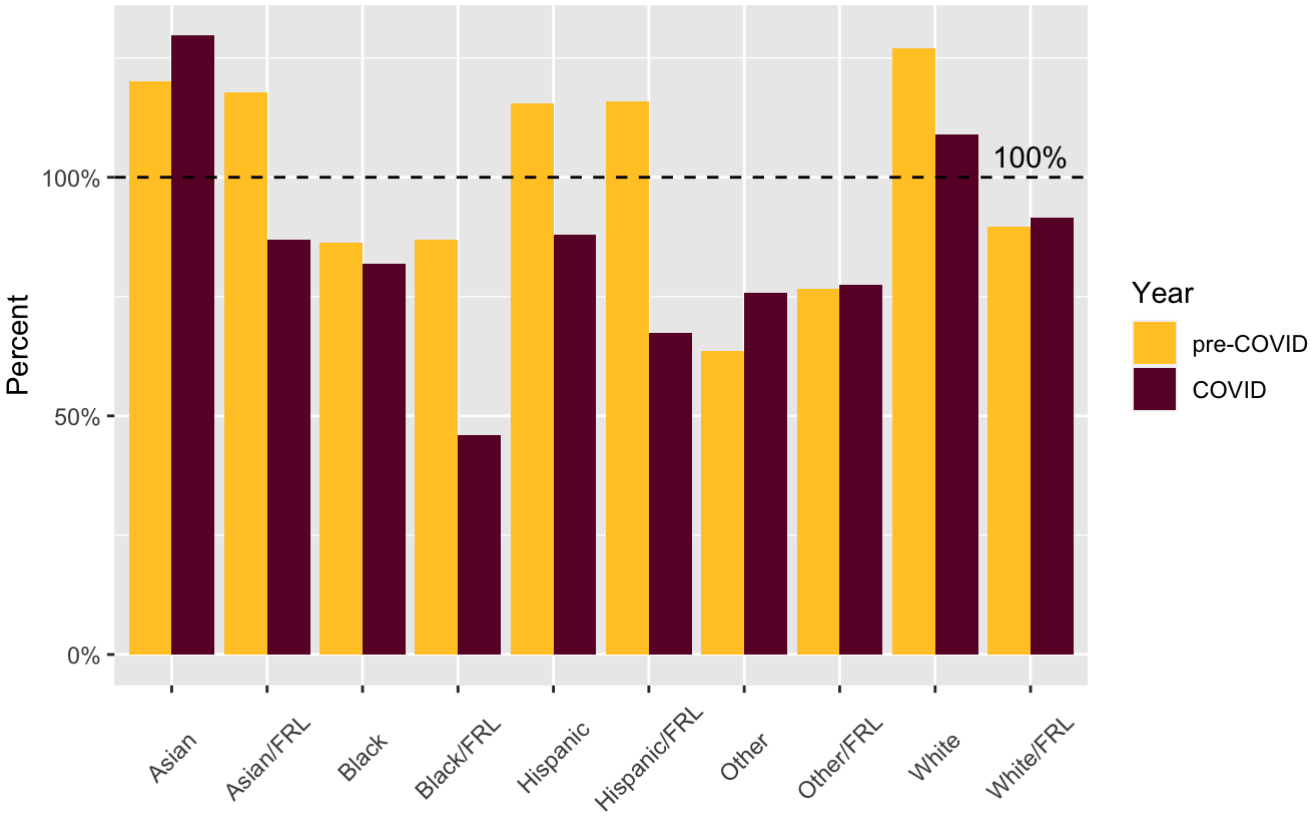
Why then do we not see a similar average learning loss in reading as we do in mathematics? It is likely that reading opportunities are much more wide spread outside of school learning. It is possible that parents were more likely to encourage students to pick up a book or read online. It is also possible that parents were less likely to have access to or encourage engagement with mathematics opportunities outside of school.

Reading - Gaps as percent of normative growth



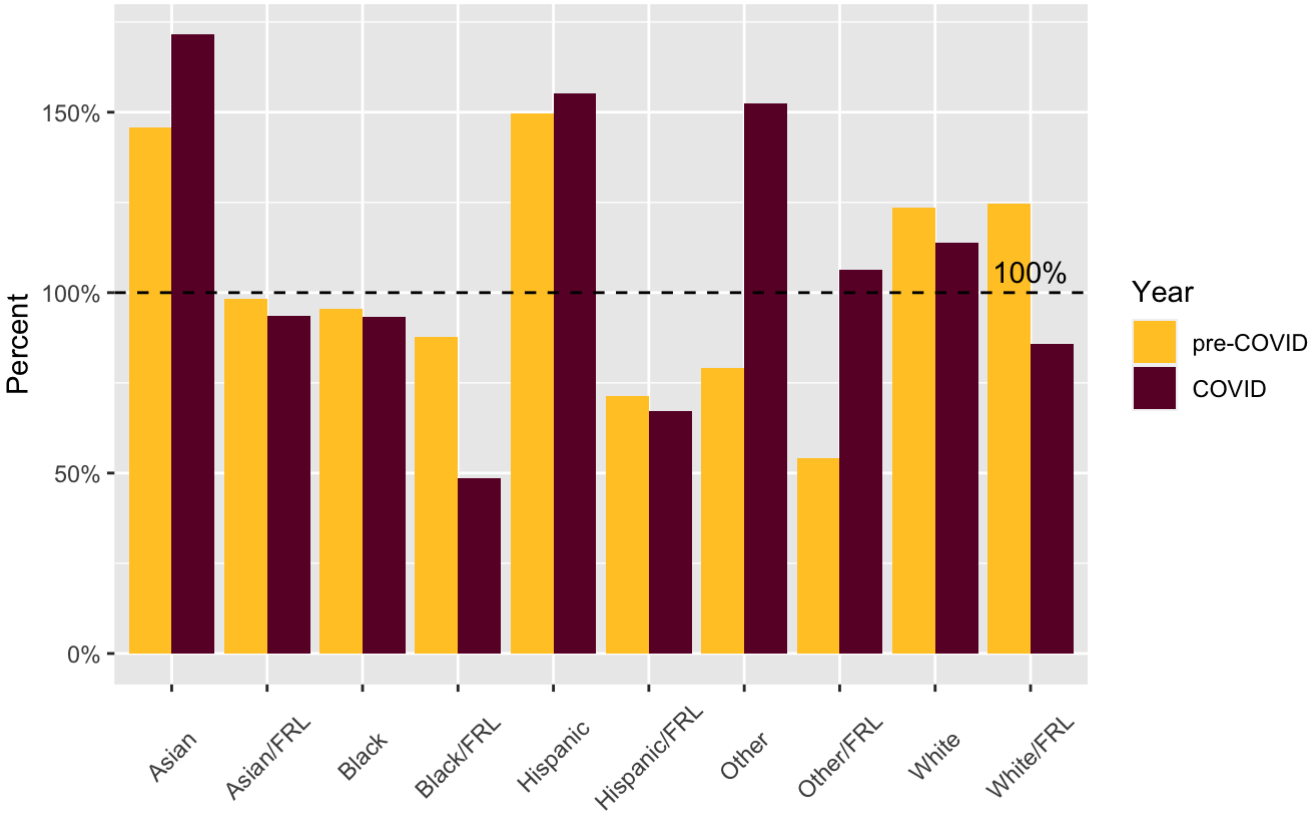
Grade 4, Reading

Group Average Growth as percent of Norm Growth



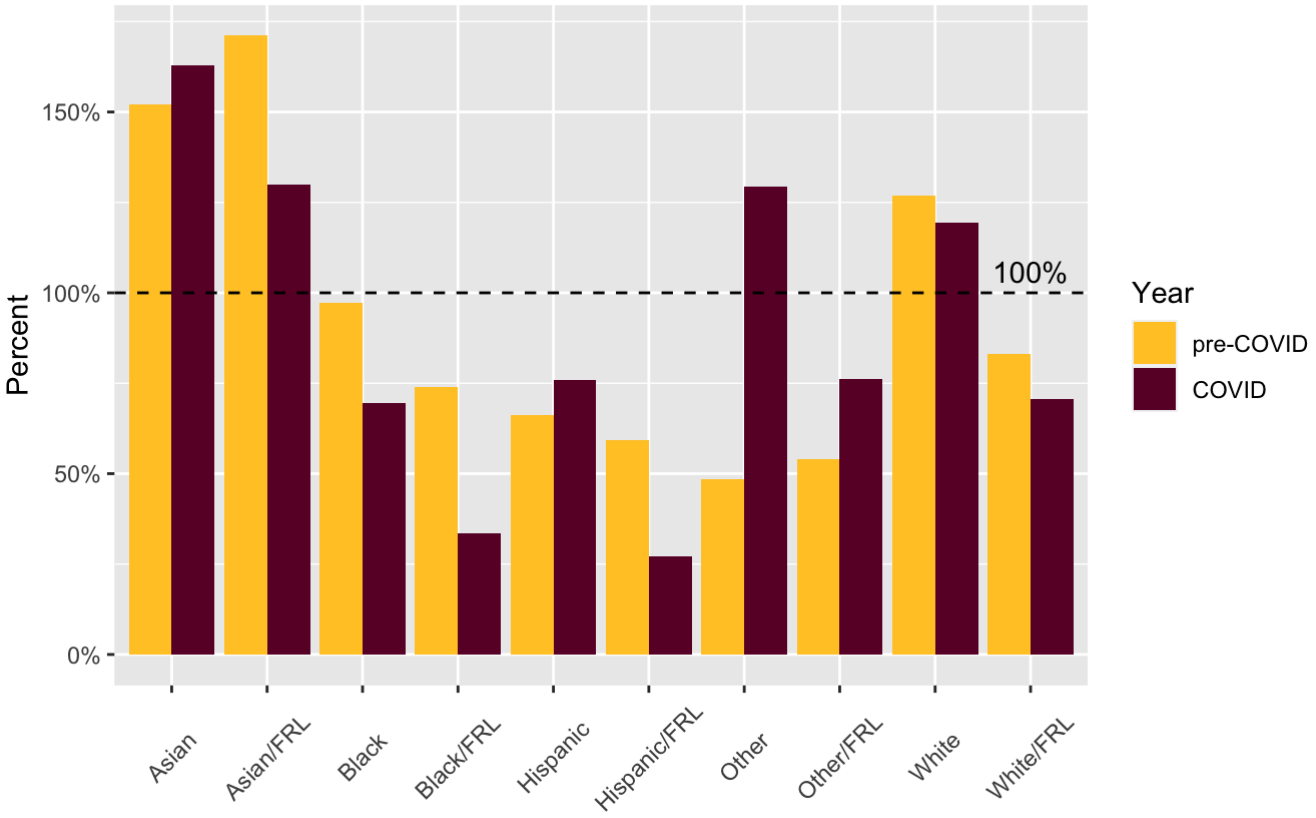
Grade 5, Reading

Group Average Growth as percent of Norm Growth



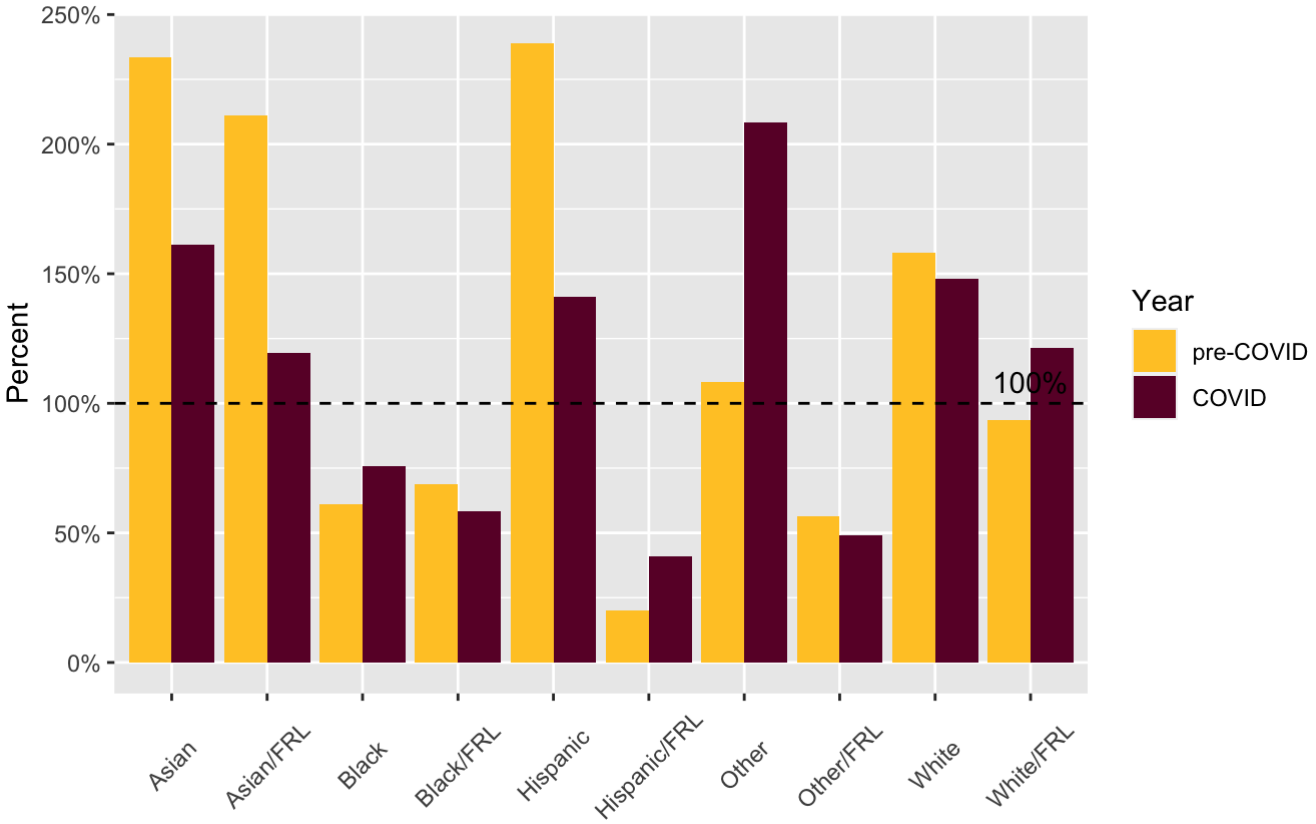
Grade 6, Reading

Group Average Growth as percent of Norm Growth



Grade 7, Reading

Group Average Growth as percent of Norm Growth



Piecewise Growth Model

To address our final question, “How have student achievement trajectories changed since the pandemic was declared?” we turn to a multilevel piecewise model to estimate the change in academic growth due to COVID. We construct our model in two levels with the first level parameterized with two time variables. In this piecewise multilevel growth model, time (grade) is nested within student. The first, (a_{1it}), is attached to a coefficient for growth in the time period prior to the COVID shutdown. The second, (a_{2it}), allows for for separate coefficient (slope) for growth in the period beginning in the COVID shutdown school year.

A set of race/ethnicity and FRL covariates are included at the second (student) level. An unconditional model with no covariates was estimated first. A likelihood ratio test (LRT) confirmed that the conditional model below fit the data better than the unconditional model. Additional models were then estimated that interacted FRL and race/ethnicity, as well as, time, FRL, and race/ethnicity. Each subsequently more complex model is said to be nested within the less complex models. This allows us to continue to use the LRT as a goodness of fit test. Ultimately, the full interacted model was the best fit. Test results are omitted here for brevity but available upon request from the author. The fully interacted model is omitted from display for space considerations.

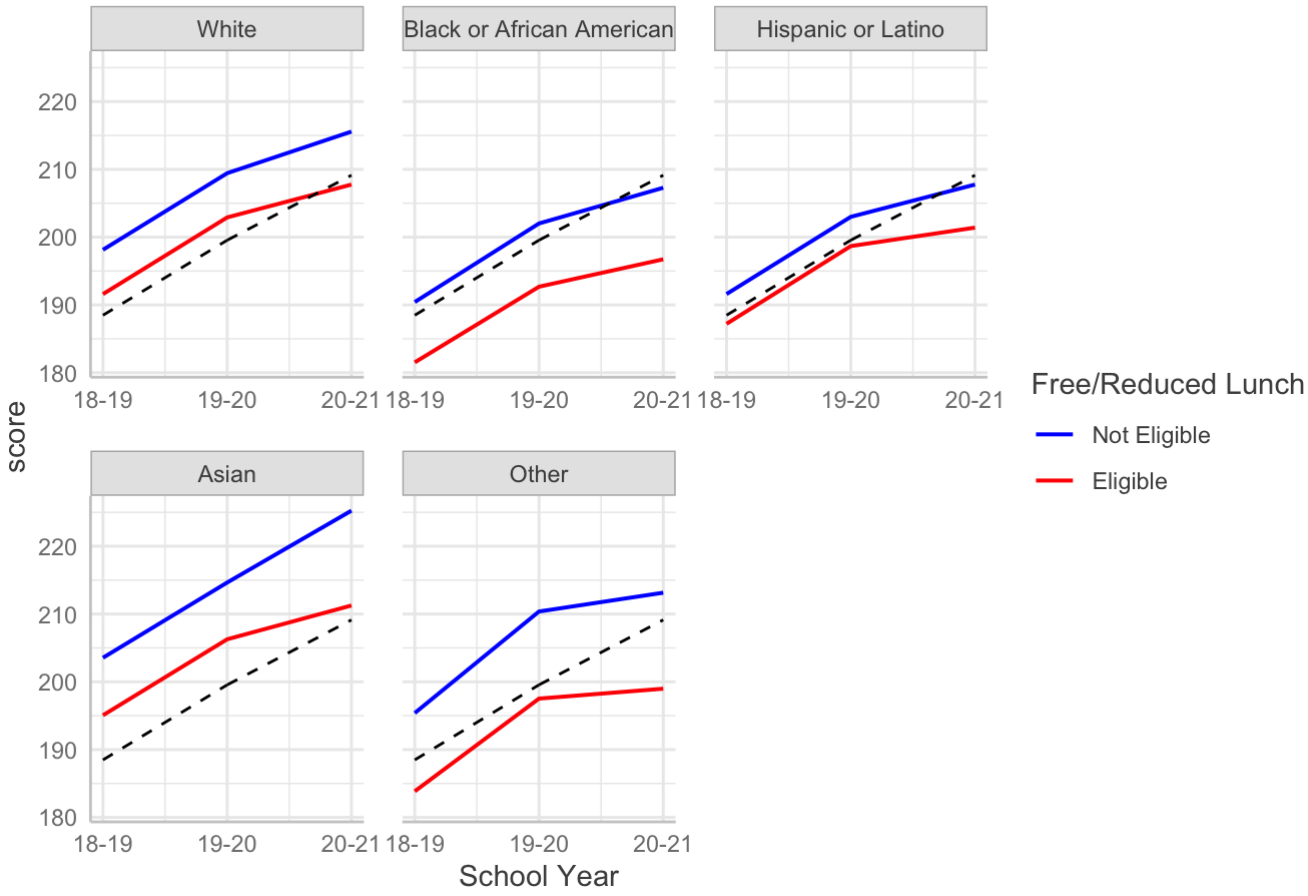
$$Y_{it} = \pi_{0i} + \pi_{1i} * a_{1it} + \pi_{2i} * a_{2it} + e_{it}$$

$$\pi_{0i} = \beta_{00} + \beta_{01} * Black_i + \beta_{02} * Hispanic_i + \beta_{03} * Asian_i + \beta_{04} * Other_i + \beta_{05} * FRL_i$$
$$\pi_{1i} = \beta_{01} + \beta_{11} * Black_i + \beta_{21} * Hispanic_i + \beta_{31} * Asian_i + \beta_{41} * Other_i + \beta_{51} * FRL_i$$
$$\pi_{2i} = \beta_{02} + \beta_{12} * Black_i + \beta_{22} * Hispanic_i + \beta_{32} * Asian_i + \beta_{42} * Other_i + \beta_{52} * FRL_i$$

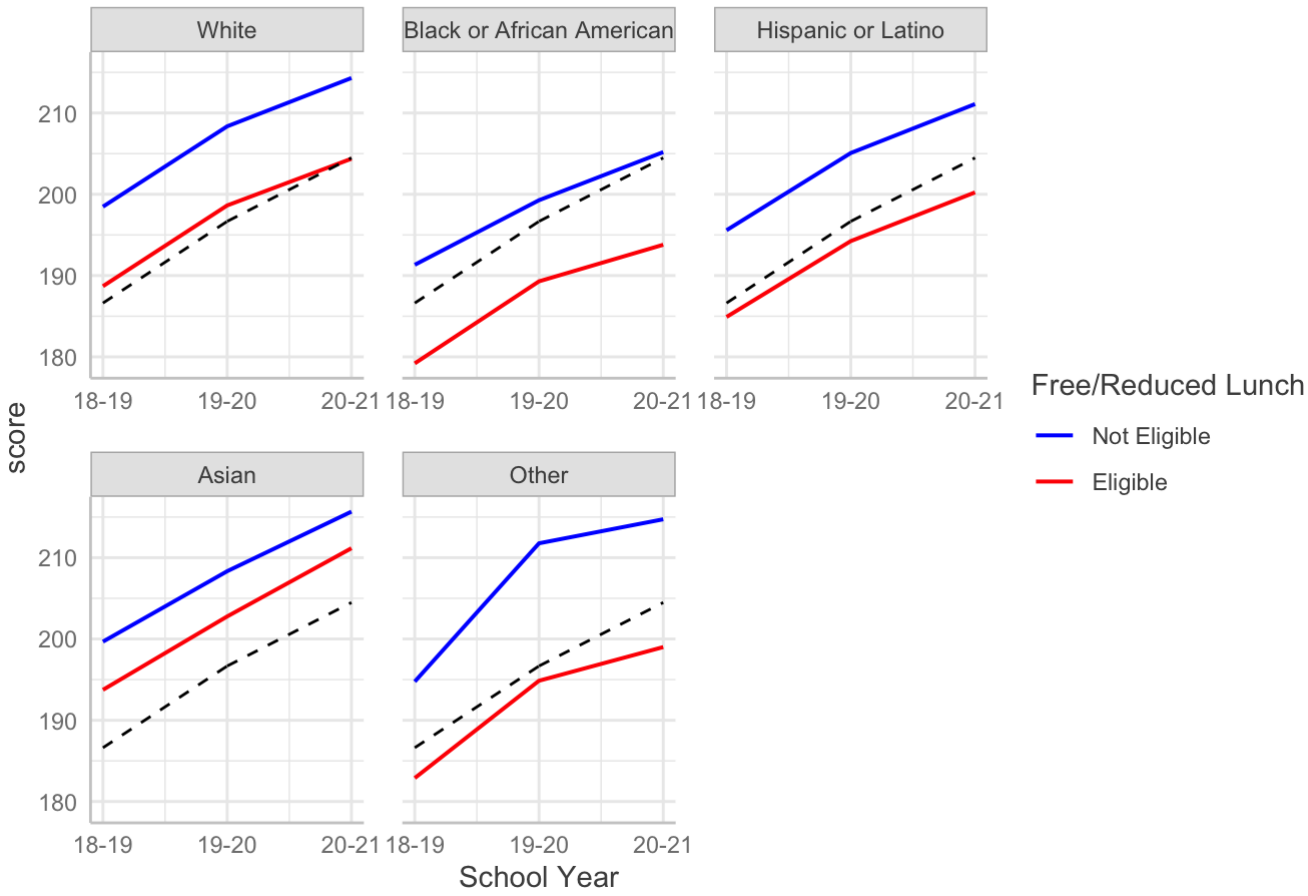
In our first model we have students who were 3rd graders in 2018-2019, 4th graders in 2019-2020 (COVID Year), and 5th graders in 2020-2021. There are about 1000 students, overall (refer to the data section for details). The intercept is allowed to vary and structural a break for the SY 2019-2020 is parameterized as time point 2. RIT score is regressed on time, time2, FRL Eligibility, Race/Ethnicity, and the interactions between all combinations of these covariates. The coefficient estimates for each model are found in Appendix C.

The expected RIT score plots are included below for mathematics and reading respectively. These plots represent the marginal effects for each group. The dashed line represents the normative achievement score at each grade level (time point). We note that fully interacting time and covariates results in marginal effects that are equivalent to the group mean at each time point. Computationally, calculating group means would be more efficient, however, this multilevel growth model allows for additional extensions and the direct estimation of variance.

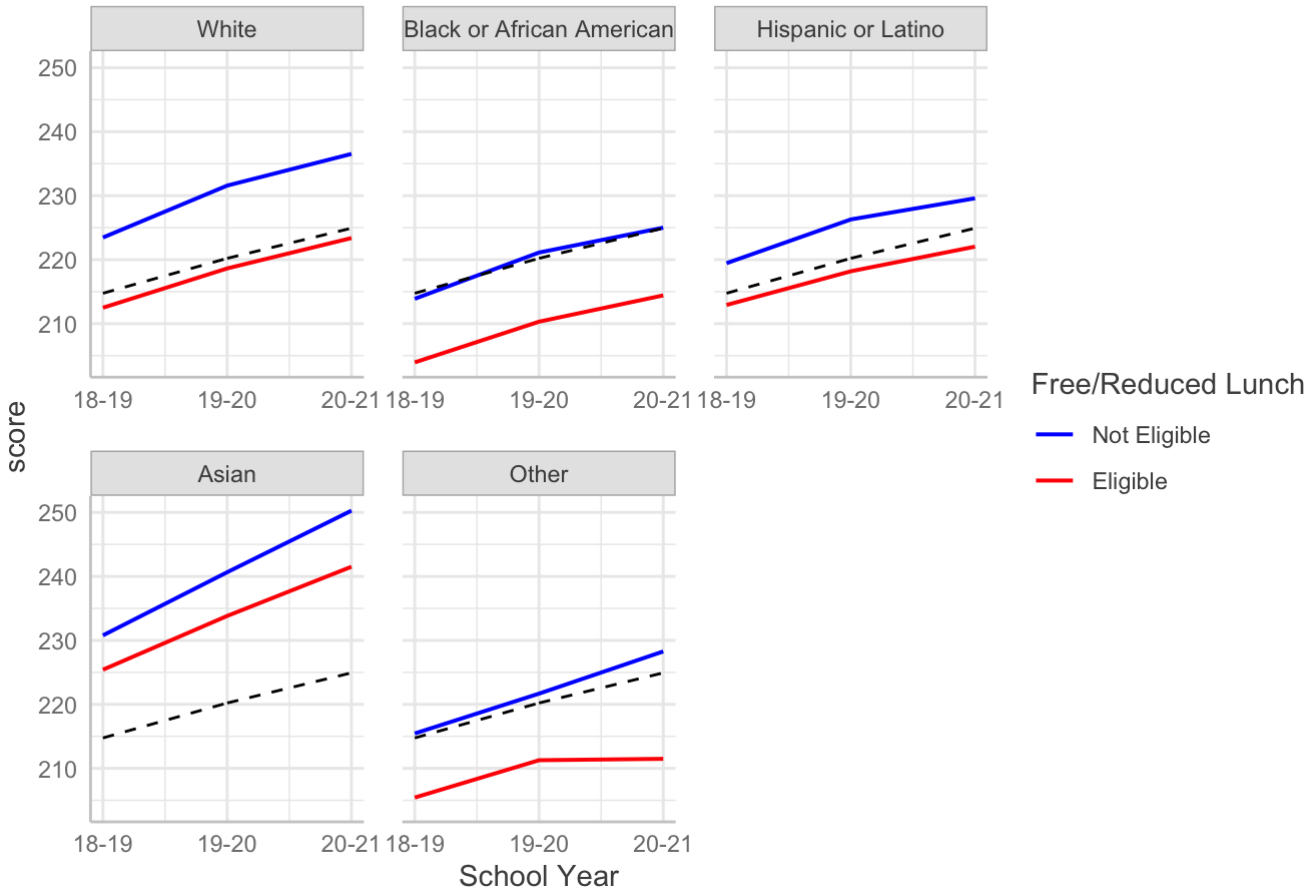
Math - Grade 3 to 5



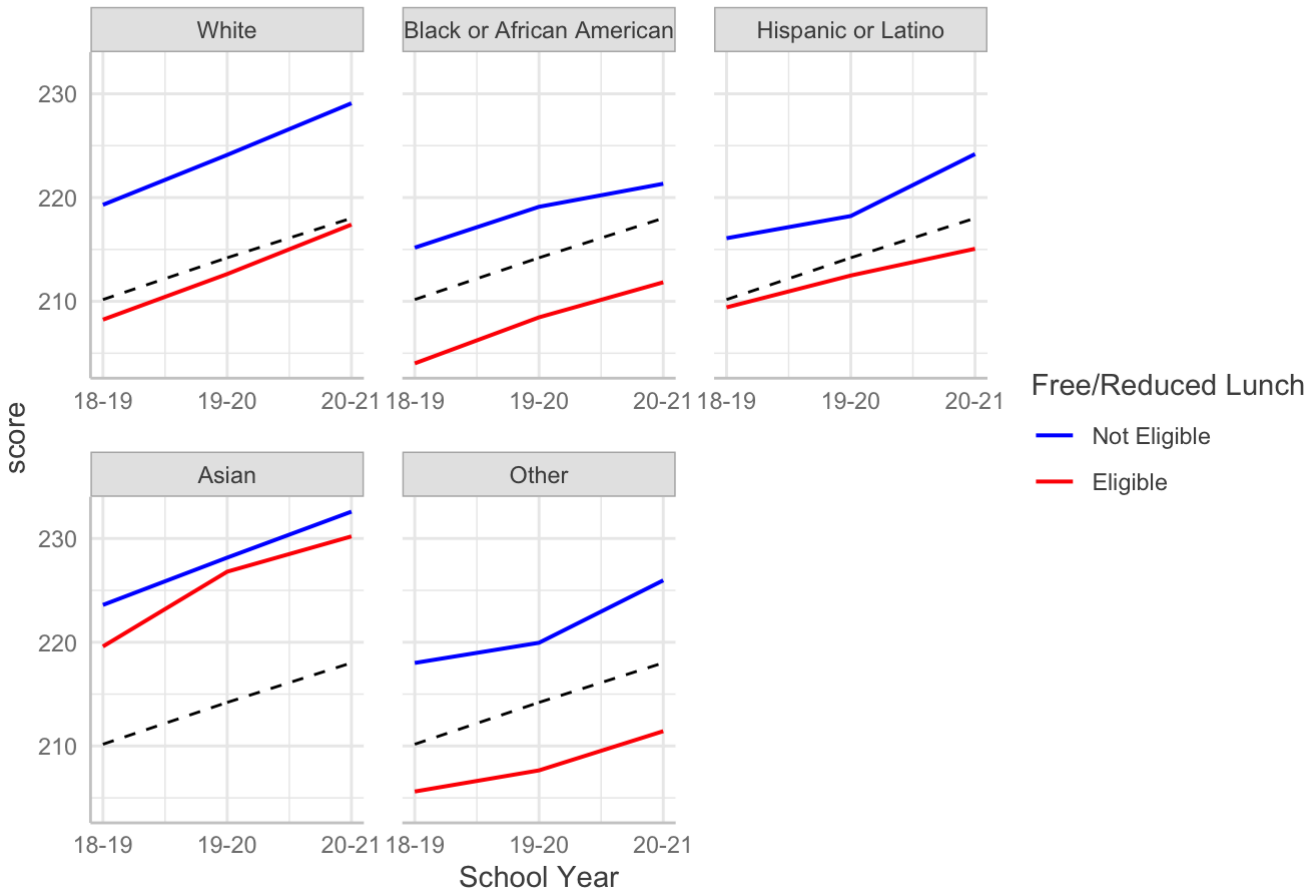
Reading - Grade 3 to 5



Math - Grade 6 to 8



Reading - Grade 6 to 8



For nearly all demographic groups, growth in the COVID school year declined. There are a couple of notable exceptions. Non-FRL Asian students saw consistent growth in both reading and mathematics in both time periods. Asian/FRL students, however, did see declines.

The most important result of these analyses is that FRL students have moved further below the normative benchmark in nearly every minority group. That is, the growth trajectory of FRL students has shifted downward and in general, further away from the benchmark. This is a troubling trend. It is possible that these students will rebound as we move back towards normalcy. Strong efforts to help students catch up to benchmarks have been moderately successful in the past. Today, those efforts are more important than ever.

Summary

It is encouraging to see growth trajectories for some groups in reading remain consistent even during the COVID pandemic. It is important, however, to understand why some students saw gains as others struggled. Research has consistently indicated that access to high quality curriculum is a major predictor of academic growth and achievement. Additionally, OTL research has consistently demonstrated that the SES is moderated by access to high quality curriculum. When efforts are made to provide high quality opportunity to learn across demographic boundaries, achievement gaps close.

The closing of schools provides counterfactual evidence of the positive effect of schools on equity gaps in achievement and growth. A reduction in school based learning time has led to some increases in achievement and growth gaps between disadvantaged students and their peers. We should not lose sight of the fact, however, that all students have struggled with loss of educational opportunities.

We hope that the COVID impact is only a one time shock to student growth and achievement. As efforts are made to reach student's with educational support in spite of pandemic restrictions, student growth and achievement should rebound. The key questions will be "How much growth and achievement can we regain?" and "Are all students able to enjoy those gains?" Further, what additional resources will be necessary to fully counter the effects of the COVID pandemic.

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Appendix A

Mathematics

Grade 3, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	36.99	29.30 – 44.69	**<0.001**
Fall 2018 RIT	-0.13	-0.17 – -0.09	**<0.001**
FRL Eligible	-0.95	-2.26 – 0.36	0.153
Asian	-1.12	-2.82 – 0.58	0.196
Black	-0.43	-1.91 – 1.05	0.567
Hispanic	0.69	-0.70 – 2.08	0.332
Other	1.56	-2.04 – 5.16	0.395
FRL/Asain	-0.09	-2.03 – 1.85	0.927
FRL/Black	0.27	-1.85 – 2.39	0.802
FRL/Hisp	-0.83	-3.18 – 1.52	0.490
FRL/Other	0.22	-4.30 – 4.74	0.925
Observations	1313		
R^2 / R^2 adjusted	0.061 / 0.054		

Grade 3, Mathematics - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	45.55	32.13 – 58.97	**<0.001**
Fall 2018 RIT	-0.19	-0.26 – -0.12	**<0.001**
FRL Eligible	-2.57	-4.05 – -1.09	**0.001**
Asian	-1.79	-4.37 – 0.80	0.176
Black	-0.43	-2.42 – 1.56	0.674
Hispanic	2.91	0.59 – 5.23	**0.014**
Other	-1.30	-3.85 – 1.24	0.316
FRL/Asain	-0.71	-3.70 – 2.27	0.640
FRL/Black	-0.54	-3.02 – 1.95	0.672
FRL/Hisp	0.24	-2.33 – 2.81	0.853
FRL/Other	-2.16	-6.81 – 2.49	0.363

Observations	1542
R^2 / R^2 adjusted	0.083 / 0.077

Grade 4, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	12.21	3.07 – 21.36	**0.009**
Fall 2018 RIT	-0.01	-0.06 – 0.04	0.746
FRL Eligible	-1.56	-3.16 – 0.05	0.057
Asian	-2.23	-4.18 – -0.27	**0.025**
Black	1.36	-0.72 – 3.45	0.200
Hispanic	2.88	0.77 – 5.00	**0.008**
Other	-1.34	-5.99 – 3.31	0.572
FRL/Asain	1.62	-0.67 – 3.91	0.165
FRL/Black	-1.15	-3.59 – 1.28	0.352
FRL/Hisp	-3.83	-6.27 – -1.39	**0.002**
FRL/Other	0.82	-4.11 – 5.74	0.745
Observations	1267		
R^2 / R^2 adjusted	0.034 / 0.026		

Grade 4, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	26.46	15.99 – 36.92	**<0.001**
Fall 2018 RIT	-0.10	-0.15 – -0.05	**<0.001**
FRL Eligible	-2.06	-3.82 – -0.31	**0.021**
Asian	-0.59	-3.00 – 1.82	0.632
Black	-2.06	-4.90 – 0.78	0.154
Hispanic	4.83	1.72 – 7.93	**0.002**
Other	-1.36	-4.27 – 1.56	0.361
FRL/Asain	-0.46	-3.08 – 2.15	0.727
FRL/Black	1.14	-1.83 – 4.11	0.451
FRL/Hisp	-3.11	-5.66 – -0.56	**0.017**
FRL/Other	-0.56	-3.48 – 2.36	0.706
Observations	1506		

R^2 / R^2 adjusted	0.054 / 0.048

Grade 5, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	28.25	22.90 – 33.61	**<0.001**
Fall 2018 RIT	-0.11	-0.13 – -0.08	**<0.001**
FRL Eligible	-1.66	-3.29 – -0.02	**0.047**
Asian	-3.67	-5.80 – -1.55	**0.001**
Black	-3.93	-6.36 – -1.49	**0.002**
Hispanic	3.44	0.55 – 6.33	**0.020**
Other	-3.98	-7.21 – -0.75	**0.016**
FRL/Asain	3.13	0.69 – 5.56	**0.012**
FRL/Black	2.29	-0.93 – 5.51	0.163
FRL/Hisp	-3.03	-7.32 – 1.27	0.167
FRL/Other	1.44	-2.19 – 5.07	0.436
Observations	1286		
R^2 / R^2 adjusted	0.075 / 0.068		

Grade 5, Mathematics - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	40.86	32.45 – 49.27	**<0.001**
Fall 2018 RIT	-0.18	-0.22 – -0.14	**<0.001**
FRL Eligible	-1.37	-3.03 – 0.28	0.104
Asian	-1.99	-3.59 – -0.40	**0.014**
Black	0.69	-2.10 – 3.47	0.630
Hispanic	3.10	1.92 – 4.27	**<0.001**
Other	-2.56	-5.80 – 0.67	0.120
FRL/Asain	0.11	-1.91 – 2.14	0.913
FRL/Black	-2.62	-5.88 – 0.64	0.115
FRL/Hisp	-2.84	-4.88 – -0.79	**0.007**
FRL/Other	0.50	-3.13 – 4.14	0.786
Observations	1337		

R^2 / R^2 adjusted	0.102 / 0.095

Grade 6, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	15.00	5.77 – 24.22	**0.001**
Fall 2018 RIT	-0.03	-0.07 – 0.01	0.134
FRL Eligible	-2.14	-3.29 – -0.99	**<0.001**
Asian	-0.84	-2.46 – 0.79	0.311
Black	-1.94	-4.82 – 0.94	0.187
Hispanic	2.73	1.26 – 4.20	**<0.001**
Other	-3.11	-5.37 – -0.85	**0.007**
FRL/Asain	0.69	-1.03 – 2.41	0.431
FRL/Black	0.83	-3.23 – 4.89	0.689
FRL/Hisp	0.53	-1.65 – 2.71	0.632
FRL/Other	3.33	0.60 – 6.05	**0.017**
Observations	1274		
R^2 / R^2 adjusted	0.030 / 0.022		

Grade 6, Mathematics - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	20.44	10.89 – 29.99	**<0.001**
Fall 2018 RIT	-0.07	-0.12 – -0.03	**0.002**
FRL Eligible	-1.08	-2.25 – 0.09	0.070
Asian	-1.41	-3.45 – 0.63	0.175
Black	-0.06	-2.24 – 2.13	0.959
Hispanic	3.78	1.54 – 6.03	**0.001**
Other	-1.32	-4.25 – 1.61	0.378
FRL/Asain	0.48	-1.72 – 2.67	0.671
FRL/Black	0.56	-2.76 – 3.87	0.741
FRL/Hisp	-2.81	-9.80 – 4.19	0.431
FRL/Other	0.83	-2.22 – 3.88	0.594
Observations	1280		
R^2 / R^2 adjusted	0.026 / 0.018		

Grade 7, Mathematics - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	11.99	4.32 – 19.66	**0.002**
Fall 2018 RIT	-0.02	-0.06 – 0.01	0.159
FRL Eligible	-0.37	-1.49 – 0.75	0.519
Asian	-1.71	-3.42 – -0.00	**0.050**
Black	0.25	-2.26 – 2.76	0.846
Hispanic	3.90	2.57 – 5.23	**<0.001**
Other	-2.29	-3.75 – -0.84	**0.002**
FRL/Asain	0.19	-2.14 – 2.52	0.873
FRL/Black	0.20	-3.60 – 4.00	0.917
FRL/Hisp	-2.78	-7.44 – 1.88	0.241
FRL/Other	1.36	-0.27 – 2.99	0.103
Observations	1241		
R^2 / R^2 adjusted	0.027 / 0.019		

Grade 7, Mathematics - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	22.08	13.23 – 30.93	**<0.001**
Fall 2018 RIT	-0.07	-0.11 – -0.04	**<0.001**
FRL Eligible	-0.60	-2.31 – 1.11	0.492
Asian	-2.01	-4.20 – 0.17	0.071
Black	-1.85	-5.21 – 1.50	0.279
Hispanic	5.39	3.28 – 7.50	**<0.001**
Other	-1.78	-4.90 – 1.34	0.263
FRL/Asain	0.50	-1.83 – 2.83	0.677
FRL/Black	-0.12	-3.97 – 3.74	0.953
FRL/Hisp	-1.96	-4.43 – 0.50	0.119
FRL/Other	-2.38	-7.72 – 2.95	0.381
Observations	1289		
R^2 / R^2 adjusted	0.043 / 0.035		

Reading

Grade 3, Reading - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	45.19	36.82 – 53.56	**<0.001**
Fall 2018 RIT	-0.18	-0.22 – -0.14	**<0.001**
FRL Eligible	-1.62	-2.94 – -0.31	**0.016**
Asian	-2.32	-4.26 – -0.38	**0.019**
Black	-0.42	-2.96 – 2.12	0.745
Hispanic	-0.93	-2.60 – 0.74	0.275
Other	4.09	-1.65 – 9.83	0.162
FRL/Asain	0.96	-1.25 – 3.16	0.395
FRL/Black	-0.33	-3.31 – 2.66	0.830
FRL/Hisp	0.13	-2.56 – 2.82	0.926
FRL/Other	-1.44	-7.85 – 4.97	0.659
Observations	1310		
R^2 / R^2 adjusted	0.110 / 0.103		

Grade 3, Reading - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	62.62	53.52 – 71.72	**<0.001**
Fall 2018 RIT	-0.27	-0.31 – -0.22	**<0.001**
FRL Eligible	-4.64	-6.13 – -3.14	**<0.001**
Asian	-2.32	-4.35 – -0.29	**0.025**
Black	-0.57	-4.05 – 2.91	0.747
Hispanic	3.05	1.31 – 4.79	**0.001**
Other	-2.21	-4.46 – 0.05	0.055
FRL/Asain	1.53	-0.94 – 4.00	0.224
FRL/Black	1.37	-2.60 – 5.34	0.497
FRL/Hisp	2.31	-3.62 – 8.23	0.445
FRL/Other	0.34	-1.58 – 2.25	0.731
Observations	1554		
R^2 / R^2 adjusted	0.137 / 0.132		

Grade 4, Reading - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	48.10	38.51 – 57.69	**<0.001**
Fall 2018 RIT	-0.19	-0.24 – -0.15	**<0.001**
FRL Eligible	-2.86	-4.65 – -1.07	**0.002**
Asian	-3.11	-5.31 – -0.90	**0.006**
Black	-0.88	-2.56 – 0.81	0.307
Hispanic	-0.53	-2.22 – 1.17	0.543
Other	-4.84	-8.89 – -0.78	**0.019**
FRL/Asain	2.90	0.60 – 5.20	**0.014**
FRL/Black	2.89	-0.19 – 5.97	0.066
FRL/Hisp	2.68	-1.03 – 6.40	0.156
FRL/Other	3.85	-0.72 – 8.42	0.099
Observations	1269		
R^2 / R^2 adjusted	0.125 / 0.118		

Grade 4, Reading - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	48.22	36.33 – 60.10	**<0.001**
Fall 2018 RIT	-0.20	-0.26 – -0.15	**<0.001**
FRL Eligible	-1.32	-2.75 – 0.10	0.069
Asian	-2.07	-4.04 – -0.10	**0.039**
Black	-1.60	-4.19 – 0.99	0.226
Hispanic	1.58	-0.24 – 3.40	0.088
Other	-2.54	-4.74 – -0.34	**0.024**
FRL/Asain	-1.41	-3.35 – 0.52	0.152
FRL/Black	-0.25	-3.27 – 2.76	0.869
FRL/Hisp	-1.95	-6.82 – 2.93	0.434
FRL/Other	1.46	-1.16 – 4.09	0.275
Observations	1509		
R^2 / R^2 adjusted	0.105 / 0.099		

Grade 5, Reading - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	45.16	37.60 – 52.71	**<0.001**
Fall 2018 RIT	-0.19	-0.22 – -0.15	**<0.001**
FRL Eligible	0.06	-1.80 – 1.92	0.951
Asian	-1.64	-3.60 – 0.31	0.100
Black	1.52	-2.03 – 5.07	0.400
Hispanic	1.29	-0.76 – 3.34	0.217
Other	-2.59	-5.27 – 0.09	0.058
FRL/Asain	-0.50	-3.10 – 2.11	0.709
FRL/Black	-4.62	-8.63 – -0.62	**0.024**
FRL/Hisp	-2.83	-8.02 – 2.37	0.286
FRL/Other	-1.51	-4.68 – 1.67	0.351
Observations	1286		
R^2 / R^2 adjusted	0.120 / 0.113		

Grade 5, Reading - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	46.45	35.07 – 57.83	**<0.001**
Fall 2018 RIT	-0.20	-0.25 – -0.14	**<0.001**
FRL Eligible	-1.63	-3.73 – 0.48	0.131
Asian	-1.19	-3.73 – 1.34	0.356
Black	2.41	-1.32 – 6.15	0.206
Hispanic	3.36	1.90 – 4.83	**<0.001**
Other	2.25	-1.84 – 6.34	0.281
FRL/Asain	-0.98	-3.99 – 2.03	0.523
FRL/Black	-3.50	-7.57 – 0.58	0.093
FRL/Hisp	-2.92	-6.00 – 0.17	0.064
FRL/Other	-1.05	-5.93 – 3.83	0.672
Observations	1341		
R^2 / R^2 adjusted	0.104 / 0.097		

Grade 6, Reading - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	43.52	34.65 – 52.38	**<0.001**
Fall 2018 RIT	-0.18	-0.22 – -0.14	**<0.001**
FRL Eligible	-2.07	-3.61 – -0.53	**0.009**
Asian	-1.40	-3.22 – 0.41	0.130
Black	-2.87	-6.45 – 0.71	0.116
Hispanic	1.20	-0.98 – 3.38	0.280
Other	-3.71	-5.62 – -1.80	**<0.001**
FRL/Asain	0.98	-1.85 – 3.81	0.496
FRL/Black	1.74	-2.03 – 5.52	0.366
FRL/Hisp	2.96	-0.60 – 6.52	0.103
FRL/Other	2.33	-0.81 – 5.47	0.146
Observations	1269		
R^2 / R^2 adjusted	0.095 / 0.087		

Grade 6, Reading - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	40.67	32.03 – 49.31	**<0.001**
Fall 2018 RIT	-0.17	-0.21 – -0.13	**<0.001**
FRL Eligible	-2.31	-3.74 – -0.89	**0.001**
Asian	-2.36	-5.00 – 0.29	0.081
Black	-2.05	-5.51 – 1.41	0.244
Hispanic	2.05	0.53 – 3.58	**0.008**
Other	0.48	-2.10 – 3.06	0.717
FRL/Asain	0.60	-2.64 – 3.84	0.715
FRL/Black	0.00	-4.31 – 4.31	0.999
FRL/Hisp	0.76	-3.77 – 5.29	0.742
FRL/Other	-0.20	-3.71 – 3.31	0.909
Observations	1291		
R^2 / R^2 adjusted	0.076 / 0.069		

Grade 7, Reading - Pre-COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	47.51	40.74 – 54.29	**<0.001**
Fall 2018 RIT	-0.19	-0.22 – -0.16	**<0.001**
FRL Eligible	-2.65	-3.91 – -1.39	**<0.001**
Asian	-3.99	-6.30 – -1.68	**0.001**
Black	3.31	1.25 – 5.38	**0.002**
Hispanic	3.10	1.83 – 4.36	**<0.001**
Other	-2.05	-4.00 – -0.09	**0.040**
FRL/Asain	2.96	0.50 – 5.43	**0.019**
FRL/Black	-6.34	-9.36 – -3.31	**<0.001**
FRL/Hisp	1.74	-3.32 – 6.79	0.500
FRL/Other	0.53	-2.96 – 4.01	0.767
Observations	1232		
R^2 / R^2 adjusted	0.135 / 0.128		

Grade 7, Reading - COVID Year

	Fall to Fall Growth		
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	40.49	33.85 – 47.13	**<0.001**
Fall 2018 RIT	-0.16	-0.19 – -0.13	**<0.001**
FRL Eligible	-1.11	-2.25 – 0.03	0.057
Asian	-2.98	-5.01 – -0.96	**0.004**
Black	-0.28	-1.82 – 1.25	0.719
Hispanic	0.54	-1.16 – 2.25	0.530
Other	2.48	0.14 – 4.81	**0.038**
FRL/Asain	0.40	-1.93 – 2.74	0.734
FRL/Black	-3.01	-5.02 – -1.01	**0.003**
FRL/Hisp	-0.62	-3.66 – 2.42	0.688
FRL/Other	-5.44	-8.95 – -1.93	**0.002**
Observations	1293		
R^2 / R^2 adjusted	0.076 / 0.068		

Appendix B

Mathematics

Grade 3 Math Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	1.11	0.00	-1.29
Black	-1.12	-0.01	-1.79	-3.08
Hispanic	-0.43	0.68	-0.43	-1.72
Asian	0.69	1.79	2.91	1.62
Other	1.56	2.67	-1.30	-2.59
White/FRL	-0.95	0.15	-2.57	-3.86
Black/FRL	-2.16	-1.06	-5.07	-6.36
Hispanic/FRL	-1.12	-0.01	-3.54	-4.83
Asian/FRL	-1.10	0.01	0.58	-0.71
Other/FRL	0.82	1.93	-6.03	-7.32

Grade 4 Math Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	0.95	0.00	-2.69
Black	-2.23	-1.28	-0.59	-3.28
Hispanic	1.36	2.32	-2.06	-4.75
Asian	2.88	3.84	4.83	2.13
Other	-1.34	-0.39	-1.36	-4.05
White/FRL	-1.56	-0.60	-2.06	-4.76
Black/FRL	-2.16	-1.21	-3.12	-5.81
Hispanic/FRL	-1.35	-0.39	-2.98	-5.68
Asian/FRL	-2.50	-1.55	-0.35	-3.05
Other/FRL	-2.08	-1.12	-3.98	-6.68

Grade 5 Math Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	0.53	0.00	-1.99
Black	-3.67	-3.14	-1.99	-3.98
Hispanic	-3.93	-3.40	0.69	-1.30
Asian	3.44	3.97	3.10	1.11
Other	-3.98	-3.45	-2.56	-4.55
White/FRL	-1.66	-1.13	-1.37	-3.36
Black/FRL	-2.20	-1.67	-3.25	-5.24
Hispanic/FRL	-3.29	-2.76	-3.31	-5.29
Asian/FRL	-1.24	-0.71	-1.12	-3.10
Other/FRL	-4.20	-3.67	-3.43	-5.42

Grade 6 Math Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	1.04	0.00	-1.72
Black	-0.84	0.20	-1.41	-3.13
Hispanic	-1.94	-0.90	-0.06	-1.78
Asian	2.73	3.77	3.78	2.06
Other	-3.11	-2.07	-1.32	-3.04
White/FRL	-2.14	-1.10	-1.08	-2.80
Black/FRL	-2.29	-1.25	-2.01	-3.73
Hispanic/FRL	-3.25	-2.21	-0.58	-2.30
Asian/FRL	1.12	2.16	-0.10	-1.83
Other/FRL	-1.92	-0.88	-1.56	-3.29

Grade 7 Math Growth Gaps

	Pre-COVID		COVID	

Group	White/Non FRL Gap	Pre-COVID Gap to Norm Growth	White/Non FRL Gap	COVID Gap to Norm Growth
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	0.87	0.00	-0.17
Black	-1.71	-0.84	-2.01	-2.18
Hispanic	0.25	1.12	-1.85	-2.02
Asian	3.90	4.77	5.39	5.22
Other	-2.29	-1.42	-1.78	-1.95
White/FRL	-0.37	0.50	-0.60	-0.77
Black/FRL	-1.89	-1.02	-2.12	-2.29
Hispanic/FRL	0.08	0.95	-2.57	-2.74
Asian/FRL	0.75	1.62	2.83	2.66
Other/FRL	-1.30	-0.43	-4.77	-4.93

Reading

Grade 3 Reading Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	1.40	0.00	2.37
Black	-2.32	-0.92	-2.32	0.04
Hispanic	-0.42	0.98	-0.57	1.80
Asian	-0.93	0.47	3.05	5.41
Other	4.09	5.49	-2.21	0.16
White/FRL	-1.62	-0.22	-4.64	-2.27
Black/FRL	-2.99	-1.59	-5.43	-3.06
Hispanic/FRL	-2.37	-0.97	-3.84	-1.47
Asian/FRL	-2.43	-1.02	0.72	3.08
Other/FRL	1.02	2.43	-6.51	-4.14

Grade 4 Reading Growth Gaps

	Pre-COVID		COVID	

Group	White/Non FRL Gap	Pre-COVID Gap to Norm Growth	White/Non FRL Gap	COVID Gap to Norm Growth
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	2.06	0.00	0.68
Black	-3.11	-1.05	-2.07	-1.39
Hispanic	-0.88	1.18	-1.60	-0.92
Asian	-0.53	1.53	1.58	2.27
Other	-4.84	-2.78	-2.54	-1.86
White/FRL	-2.86	-0.80	-1.32	-0.64
Black/FRL	-3.06	-1.00	-4.81	-4.12
Hispanic/FRL	-0.84	1.22	-3.18	-2.49
Asian/FRL	-0.70	1.36	-1.69	-1.00
Other/FRL	-3.85	-1.79	-2.40	-1.72

Grade 5 Reading Growth Gaps

	Pre-COVID		COVID	
Group	**White/Non FRL Gap**	**Gap to Norm Growth**	**White/Non FRL Gap**	**Gap to Norm Growth**
White	0.00	1.37	0.00	0.80
Black	-1.64	-0.27	-1.19	-0.39
Hispanic	1.52	2.90	2.41	3.21
Asian	1.29	2.66	3.36	4.17
Other	-2.59	-1.22	2.25	3.05
White/FRL	0.06	1.43	-1.63	-0.82
Black/FRL	-2.08	-0.71	-3.80	-3.00
Hispanic/FRL	-3.04	-1.67	-2.71	-1.91
Asian/FRL	-1.48	-0.11	-1.18	-0.38
Other/FRL	-4.04	-2.67	-0.43	0.37

Grade 6 Reading Growth Gaps

	Pre-COVID		COVID	

Group	Pre-COVID		COVID	
	White/Non FRL Gap	Gap to Norm Growth	White/Non FRL Gap	Gap to Norm Growth
White	0.00	1.27	0.00	0.92
Black	-1.40	-0.14	-2.36	-1.44
Hispanic	-2.87	-1.60	-2.05	-1.13
Asian	1.20	2.47	2.05	2.97
Other	-3.71	-2.44	0.48	1.40
White/FRL	-2.07	-0.80	-2.31	-1.40
Black/FRL	-2.49	-1.23	-4.07	-3.15
Hispanic/FRL	-3.20	-1.93	-4.36	-3.45
Asian/FRL	2.09	3.36	0.50	1.42
Other/FRL	-3.45	-2.18	-2.04	-1.12

Grade 7 Reading Growth Gaps

Group	Pre-COVID		COVID	
	White/Non FRL Gap	Gap to Norm Growth	White/Non FRL Gap	Gap to Norm Growth
White	0.00	2.39	0.00	1.98
Black	-3.99	-1.60	-2.98	-1.00
Hispanic	3.31	5.70	-0.28	1.70
Asian	3.10	5.48	0.54	2.52
Other	-2.05	0.34	2.48	4.45
White/FRL	-2.65	-0.26	-1.11	0.87
Black/FRL	-3.67	-1.29	-3.68	-1.71
Hispanic/FRL	-5.67	-3.28	-4.40	-2.43
Asian/FRL	2.18	4.57	-1.19	0.79
Other/FRL	-4.17	-1.78	-4.07	-2.09

Appendix C

Mathmatics, Focal Grade 4

Focal Grade 4, Mathematics

		RIT Score	
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	198.14	196.51 – 199.77	**<0.001**
Time 1	11.30	10.31 – 12.29	**<0.001**
Time 2	-5.16	-6.88 – -3.45	**<0.001**
FRL	-6.54	-9.18 – -3.90	**<0.001**
Black	-7.71	-11.40 – -4.02	**<0.001**
Hispanic	-6.53	-12.70 – -0.36	**0.038**
Asian	5.41	1.64 – 9.18	**0.005**
Other	-2.75	-10.32 – 4.82	0.477
Time 1/FRL	0.01	-1.59 – 1.62	0.987
Time 2/FRL	-1.30	-4.08 – 1.47	0.357
Time 1/Black	0.29	-1.95 – 2.53	0.800
Time 1/Hispanic	0.09	-3.66 – 3.83	0.963
Time 1/Asian	-0.20	-2.49 – 2.09	0.865
Time 1/Other	3.68	-0.92 – 8.28	0.117
Time 2/Black	-1.16	-5.04 – 2.72	0.558
Time 2/Hispanic	-1.46	-7.95 – 5.02	0.658
Time 2/Asian	4.66	0.69 – 8.63	**0.021**
Time 2/Other	-7.04	-15.01 – 0.92	0.083
FRL/Black	-2.36	-6.75 – 2.03	0.292
FRL/Hispanic	2.15	-5.02 – 9.32	0.557
FRL/Asian	-1.95	-10.23 – 6.34	0.645
FRL/Other	-5.01	-14.85 – 4.84	0.319
Time 1/FRL/Black	-0.44	-3.11 – 2.23	0.745
Time 1/FRL/Hispanic	0.06	-4.29 – 4.42	0.978
Time 1/FRL/Asian	0.10	-4.93 – 5.13	0.970
Time 1/FRL/Other	-1.32	-7.30 – 4.66	0.666

Time 2/FRL/Black	0.51	-4.11 – 5.13	0.829
Time 2/FRL/Hispanic	-0.81	-8.35 – 6.74	0.834
Time 2/FRL/Asian	-4.42	-13.14 – 4.29	0.320
Time 2/FRL/Other	1.30	-9.06 – 11.66	0.806

Random Effects

σ^2	28.87
$\tau_{00\ NWEA\_Student\_ID}$	127.60
ICC	0.82
$N_{\ NWEA\_Student\_ID}$	1022
Observations	3066
Marginal R^2 / Conditional R^2	0.411 / 0.891

Focal Grade 4, Reading

		RIT Score	
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	198.48	196.57 – 200.39	**<0.001**
Time 1	9.88	8.64 – 11.13	**<0.001**
Time 2	-3.94	-6.10 – -1.78	**<0.001**
FRL	-9.78	-12.85 – -6.72	**<0.001**
Black	-7.15	-11.50 – -2.80	**0.001**
Hispanic	-2.90	-10.12 – 4.32	0.432
Asian	1.19	-3.23 – 5.61	0.597
Other	-3.72	-12.59 – 5.15	0.411
Time 1/FRL	0.05	-1.95 – 2.05	0.960
Time 2/FRL	-0.25	-3.71 – 3.21	0.889
Time 1/Black	-1.94	-4.78 – 0.90	0.180
Time 1/Hispanic	-0.38	-5.10 – 4.33	0.873
Time 1/Asian	-1.22	-4.10 – 1.67	0.408
Time 1/Other	7.13	1.34 – 12.92	**0.016**
Time 2/Black	1.91	-3.00 – 6.83	0.445
Time 2/Hispanic	0.46	-7.70 – 8.63	0.912
Time 2/Asian	2.60	-2.40 – 7.59	0.308
Time 2/Other	-10.12	-20.14 – -0.10	**0.048**
FRL/Black	-2.35	-7.50 – 2.81	0.373

FRL/Hispanic	-0.88	-9.26 – 7.49	0.836
FRL/Asian	3.86	-5.84 – 13.55	0.436
FRL/Other	-2.09	-13.50 – 9.32	0.720
Time 1/FRL/Black	2.10	-1.27 – 5.46	0.221
Time 1/FRL/Hispanic	-0.22	-5.69 – 5.25	0.938
Time 1/FRL/Asian	0.31	-6.02 – 6.64	0.924
Time 1/FRL/Other	-5.09	-12.54 – 2.36	0.180
Time 2/FRL/Black	-3.32	-9.15 – 2.51	0.264
Time 2/FRL/Hispanic	0.38	-9.09 – 9.85	0.937
Time 2/FRL/Asian	0.95	-10.00 – 11.91	0.865
Time 2/FRL/Other	6.47	-6.42 – 19.37	0.325

Random Effects

σ^2	45.72
$\tau_{00\ NWEA\_Student\_ID}$	168.98
ICC	0.79
$N_{\ NWEA\_Student\_ID}$	1027
Observations	3081
Marginal R^2 / Conditional R^2	0.336 / 0.859

Focal Grade 7, Mathematics

		RIT Score	
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	223.47	221.63 – 225.30	**<0.001**
Time 1	8.11	7.14 – 9.09	**<0.001**
Time 2	-3.17	-4.85 – -1.48	**<0.001**
FRL	-10.97	-13.91 – -8.04	**<0.001**
Black	-9.58	-13.57 – -5.58	**<0.001**
Hispanic	-4.01	-10.60 – 2.58	0.233
Asian	7.32	2.32 – 12.31	**0.004**
Other	-8.02	-17.37 – 1.34	0.093
Time 1/FRL	-1.97	-3.53 – -0.42	**0.013**
Time 2/FRL	1.77	-0.92 – 4.46	0.197
Time 1/Black	-0.89	-3.00 – 1.23	0.411
Time 1/Hispanic	-1.28	-4.77 – 2.21	0.472

Time 1/Asian	1.75	-0.89 – 4.40	0.194
Time 1/Other	-1.89	-6.84 – 3.06	0.455
Time 2/Black	-0.17	-3.83 – 3.49	0.926
Time 2/Hispanic	-0.36	-6.41 – 5.68	0.906
Time 2/Asian	2.92	-1.66 – 7.50	0.211
Time 2/Other	3.54	-5.04 – 12.12	0.419
FRL/Black	1.04	-3.84 – 5.91	0.677
FRL/Hispanic	4.44	-3.63 – 12.52	0.281
FRL/Asian	5.61	-3.90 – 15.11	0.248
FRL/Other	0.96	-10.86 – 12.77	0.874
Time 1/FRL/Black	1.10	-1.48 – 3.69	0.402
Time 1/FRL/Hispanic	0.40	-3.87 – 4.68	0.853
Time 1/FRL/Asian	0.51	-4.52 – 5.54	0.844
Time 1/FRL/Other	1.59	-4.67 – 7.84	0.619
Time 2/FRL/Black	-0.68	-5.15 – 3.79	0.765
Time 2/FRL/Hispanic	0.34	-7.06 – 7.74	0.928
Time 2/FRL/Asian	-2.24	-10.95 – 6.48	0.615
Time 2/FRL/Other	-7.77	-18.59 – 3.06	0.160

Random Effects

σ^2	30.69
$\tau_{00\ NWEA\_Student\_ID}$	188.41
ICC	0.86
$N_{\ NWEA\_Student\_ID}$	950
Observations	2850
Marginal R^2 / Conditional R^2	0.340 / 0.908

Focal Grade 7, Reading

		RIT Score	
Coeffcient	*Estimates*	*Conf. Int (95%)*	*P-Value*
Intercept	219.30	217.64 – 220.97	**<0.001**
Time 1	4.81	3.75 – 5.86	**<0.001**
Time 2	0.17	-1.66 – 2.00	0.856
FRL	-11.07	-13.69 – -8.45	**<0.001**
Black	-4.13	-7.75 – -0.51	**0.025**

Hispanic	-3.22	-9.17 – 2.72	0.288
Asian	4.29	-0.22 – 8.80	0.062
Other	-1.30	-9.74 – 7.14	0.763
Time 1/FRL	-0.41	-2.07 – 1.25	0.627
Time 2/FRL	0.20	-2.68 – 3.08	0.893
Time 1/Black	-0.87	-3.17 – 1.43	0.459
Time 1/Hispanic	-2.67	-6.44 – 1.11	0.166
Time 1/Asian	-0.25	-3.11 – 2.61	0.864
Time 1/Other	-2.86	-8.22 – 2.49	0.295
Time 2/Black	-1.89	-5.87 – 2.10	0.353
Time 2/Hispanic	3.67	-2.87 – 10.20	0.272
Time 2/Asian	-0.29	-5.25 – 4.66	0.907
Time 2/Other	3.90	-5.38 – 13.18	0.410
FRL/Black	-0.08	-4.49 – 4.32	0.970
FRL/Hispanic	4.40	-2.88 – 11.69	0.236
FRL/Asian	7.07	-1.30 – 15.43	0.098
FRL/Other	-1.32	-11.87 – 9.22	0.806
Time 1/FRL/Black	0.91	-1.89 – 3.71	0.524
Time 1/FRL/Hispanic	1.34	-3.28 – 5.97	0.569
Time 1/FRL/Asian	3.06	-2.25 – 8.37	0.259
Time 1/FRL/Other	0.50	-6.19 – 7.20	0.883
Time 2/FRL/Black	0.46	-4.38 – 5.31	0.851
Time 2/FRL/Hispanic	-4.53	-12.54 – 3.49	0.268
Time 2/FRL/Asian	-3.88	-13.08 – 5.32	0.409
Time 2/FRL/Other	-2.52	-14.12 – 9.08	0.670

Random Effects

σ^2	35.89
$\tau_{00\ NWEA\_Student\_ID}$	142.20
ICC	0.80
$N_{\ NWEA\_Student\_ID}$	948
Observations	2844
Marginal R^2 / Conditional R^2	0.259 / 0.851