Institute for Education and Social Policy

The Effect of Breakfast in the Classroom on Obesity and Academic Performance: Evidence from New York City

Working Paper #04-14
November 2014

Sean P. Corcoran
New York University

Brian Elbel
New York University

Amy Ellen Schwartz
New York University

NYU Steinhardt
Steinhardt School of Culture, Education, and Human Development

NYU Wagner
Robert F. Wagner Graduate School of Public Service

This project was supported by Award Number 1R01HD070739 from the Eunice Kennedy Shriver National Institute of Child Health & Human Development. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health & Human Development or the National Institutes of Health. We would like to thank the New York City Department of Education, and especially the Office of SchoolFood, for providing necessary data and support. Stephen O'Brien, Armando Taddei and Dennis Barrett at the Office of School Food and Melissa Pflugh Prescott at NYU have been particularly valuable resources to this project. Siddhartha Aneja, Michele Leardo, and Elizabeth Debraggio provided outstanding research assistance.

Contact author: Sean P. Corcoran, Institute for Education and Social Policy, New York University, 665 Broadway, Suite 805, New York, NY 10012. Phone: 212-992-9468. Email: sean.corcoran@nyu.edu.

Editorial Board

ABSTRACT

Participation in the federally-subsidized school breakfast program often falls well below its lunchtime counterpart. To increase take-up, many districts have implemented Breakfast in the Classroom (BIC), offering breakfast directly to students at the start of the school day. Beyond increasing participation, advocates claim BIC improves academic performance, attendance, and engagement. Others caution BIC has deleterious effects on child weight. We use the implementation of BIC in NYC to estimate its impact on meals program participation, BMI, achievement, and attendance. While we find large effects on participation, our findings provide no evidence of hoped-for gains in academic performance, nor of feared increases in obesity. The policy case for BIC will depend upon reductions in hunger and food insecurity for disadvantaged children, or its longer-term effects.

INTRODUCTION

The federal School Breakfast Program (SBP) has subsidized breakfasts for needy children since 1966, with the aims of reducing food insecurity, improving nutrition, and facilitating learning (Bhattacharya, Currie, & Haider, 2006; Millimet, Tchernis, & Husain, 2010; Poppendieck, 2010). Participation in the SBP, however, typically falls well below that of its lunchtime counterpart (Bartfeld & Kim, 2010; Basch, 2011; Dahl & Scholz, 2011; Schanzenbach & Zaki, 2014). In New York City, for example, less than a third of all students take a breakfast each day, even though it is provided free to all and roughly three in four students live in low income households (Leos-Urbel et al., 2013).[1]

To increase participation in the SBP, a number of school districts have adopted Breakfast in the Classroom (BIC), a program that serves breakfast directly to students in the classroom at the start of the school day, rather than in the cafeteria before school. The intent is to reach students unable or unwilling to arrive early to school, and to reduce stigma associated with visiting the cafeteria before school for a subsidized meal. NYC schools began implementing BIC in 2007 and today the program is offered in nearly 300 of the city's 1,700 schools.[2]

Advocates argue that moving breakfast from the cafeteria to the classroom provides myriad benefits, including improved academic performance, attendance, and engagement, in addition to reducing child hunger and food insecurity among disadvantaged children. Indeed, there is robust evidence that the consumption, timing, and nutritional quality of breakfast affect cognitive performance (e.g., Wesnes et al., 2003; Rampersaud et al., 2005). While there has been little work evaluating BIC in particular, at least one study found that moving breakfast to the classroom can substantially improve math and reading performance (Imberman & Kugler, 2014).[3] At the same time, others have warned BIC will have deleterious effects on students' weight, increasing BMI and obesity, as participants consume more daily calories or less nutritious food than they otherwise would. In NYC, the Bloomberg administration temporarily halted expansion of BIC over this concern when an internal study found BIC students were more

[1] A 2012 report from the Food Research and Action Center rated NYC last out of 26 urban school districts in breakfast participation among subsidy-eligible students (FRAC, 2012).
[2] "It's a Hit: Breakfast in the Classroom," *The New York Times*, November 17, 2008, A21.
[3] A second unpublished paper found similar results on test scores for a subset of schools in San Diego (Dotter, 2012), although a recent paper re-analyzing data from a Department of Agriculture experiment did not (Schanzenbach and Zaki, 2014) These studies are described later.

likely to eat two breakfasts, one at home and another during school (Van Wye et al., 2013).[4] There is, however, scant research available to guide policymakers in resolving these conflicting claims, and virtually no evidence on the impact on BMI or obesity in particular. Whether the potential benefits of BIC are offset by a hidden "cost" in increased obesity is a critical question for policymakers charged with improving academic outcomes and promoting the health and well-being of students.

In this paper, we use the staggered implementation of BIC in NYC together with richly detailed longitudinal data on student height, weight, achievement, and attendance to estimate the program's impact on body mass index (BMI), obesity, academic performance and attendance. We begin by investigating whether a school's adoption of BIC had a significant impact on average daily participation in the breakfast and lunch programs. We then match school data on BIC adoption to longitudinal data on students to estimate the program's overall impact on student outcomes, including BMI.[5] Our identification strategy is a difference-in-difference, contrasting observationally similar students in schools that did and did not adopt BIC, before and after implementation. We also allow the effect of BIC to vary with the percentage of classes in the school offering the program, and by cumulative student exposure to BIC.

We find the offer of BIC in NYC schools had a substantial effect on school breakfast participation with no spillover effects on school lunch participation. Further, there is no evidence BIC increased BMI or the incidence of obesity among affected students, and nearly all our coefficient estimates suggest lower average BMI when students are offered BIC. We find insignificant effects on reading and math achievement in grades 4-8, a sharp contrast with those of Imberman and Kugler (2014). Finally, we find small positive effects of BIC on attendance rates, concentrated in middle school. While our data do not permit us to examine impacts on individual student eating behaviors, our findings are consistent with recent experimental evidence showing BIC has, at best, small effects on net breakfast consumption and nutrition (Schanzenbach & Zaki, 2014).

Taken together, BIC's large impact on participation does not appear to come at the cost of worsening childhood obesity. Whether BIC effectively reduces hunger and food insecurity

[4] "Hiccup in the Most Important Meal," *The New York Times*, April 19, 2012, A1.
[5] To be clear, our data do not include individual data on consumption. Instead, we focus on the impact of the policy change (offering breakfast in the classroom) on outcomes of policy interest that are measured at the student level.

among disadvantaged children or has longer run impacts on obesity, stigma associated with the subsidized meals program, or other outcomes remains for future work.

I. BACKGROUND

A. THE EFFECTS OF SCHOOL MEALS ON HEALTH AND ACADEMIC ACHIEVEMENT

There is considerable evidence that the availability and quality of school meals programs can affect the nutritional intake and academic outcomes of participating students. For example, in a study of the SBP, Bhattacharya, Currie, and Haider (2006) used detailed survey data from the NHANES III to investigate how access to the SBP affected children's breakfast consumption and nutrient intake. They found no impact of the SBP on total calories consumed or the likelihood of eating breakfast, but found large effects on the nutritional quality of breakfasts eaten, with fewer calories from fat, and higher serum levels of vitamins C, E, and folate. Schanzenbach (2009) examined the body weight of students participating in the school lunch program and found that children eating school lunches were more likely to be obese than those bringing their own lunch, a finding she attributed to higher caloric intake among students taking school lunches. A study by Millimet, Tchernis, and Husain (2010) corroborated this finding for school lunches, but—consistent with Bhattacharya, Currie, and Haider (2006)—found that participation in the SBP was associated with lower rates of obesity.

Evidence of a causal impact of school meals on educational outcomes is mixed, but frequently positive. In one study of the long-run effects of the school lunch program, Hinrichs (2010) found sizable effects on the educational attainment of adults who were exposed to the program early in life. In contrast, using administrative data from Chile, McEwan (2013) found no short-run effects on test scores, school attendance, and grade repetition of providing free high-calorie meals to poor children. Along the same lines, Dunifon and Kowaleski-Jones (2003) found little association between school lunch program participation in the U.S. and achievement after accounting for selection into the program.[6] In a clever study examining schools' responses to test-based accountability in Virginia, Figlio and Winicki (2005) found that schools under accountability pressure substantially increased the caloric content of their meals on test days, and saw larger increases in passing rates as a result. Consistent with this type of short-run effect, Imberman and Kugler (2014) found the introduction of BIC into a large urban school district had large positive effects on reading and math achievement, even when the program was implemented a short time before the test. (We describe this study in greater detail in Section 2.2).

That the consumption and quality of breakfast can have at least a short-run effect on child cognitive performance is confirmed in a number of experimental studies.[7] For example, a study in the U.K. randomly assigned 10-year-old students to different breakfast regimens at home and found students receiving a higher-energy breakfast scored higher on tests of creativity and number checking (Wyon et al., 1997). They were also less likely to report feeling bad or hungry. Wesnes et al. (2003) randomly assigned students to receive one of four types of breakfast on successive days (one of two types of cereal, a glucose drink, or no breakfast) and found that students eating a cereal breakfast performed better on a series of tests of attention and memory over the course of the morning. Simeon and Grantham-McGregor (1989) conducted a small experiment in which under-nourished children in the West Indies were randomly assigned to receive a breakfast or a cup of tea on alternate days.

[6] More comprehensive reviews of this literature can be found in Briefel et al. (1999), Hoyland, Dye, and Lawton (2009), Ponza et al. (1999), and Rampersaud et al. (2005).
[7] A more thorough review can be found in Pollitt and Matthews (1998) and Hoyland, Dye, and Lawton (2009).

After consuming breakfast, students performed better on cognitive tests of arithmetic and problem solving than when drinking only tea.

Relevant to BIC, one study we identified found that when breakfast is consumed relates to its effects on cognitive performance. In a randomized control trial, Vaisman et al. (1996) found that 11- to 13-year-old students who ate a regular breakfast before school (two hours before testing) performed no better than a control group on tests of cognitive functioning. However, students who ate a cereal and milk breakfast in class 30 minutes before testing performed significantly better.

B. Breakfast in the Classroom

Breakfast in the Classroom alters the traditional SBP by serving breakfast in class at the start of the school day, rather than in the cafeteria before school hours (FRAC, 2012). The intent of BIC is to increase breakfast participation among students who are unable or unwilling to arrive early to school, and to reduce stigma associated with visiting the cafeteria before school for a subsidized meal. BIC advocates have also argued the program provides an opportunity to integrate nutrition into the curriculum, as teachers can use the time to teach good eating habits. Proponents tout the social aspects of the program as well, citing the benefits of communal eating.[8]

BIC breakfasts are offered during the first 10-20 minutes of class, often during morning announcements or while the teacher takes attendance or returns homework. Meals are bagged the prior evening by school food staff, placed into insulated containers, and refrigerated overnight. They are then delivered to classrooms in the morning, or distributed to students as they arrive ("Grab and Go"). Because breakfasts are assembled the night before, BIC menus

[8] See http://www.healthyeating.org/Schools/Tips-Trends/Article-Viewer/Article/142/breakfast-at-school-a-communal-meal-that-makes-a-difference.aspx [last accessed March 1, 2013].

generally differ from those prepared in the cafeteria. Specifically, BIC meals usually consist of cold, pre-packed items such as cereal, fresh fruit, or bagels. Cafeteria breakfasts, on the other hand, include hot meals such as pancakes or egg omelets.[9] Though they may differ in menu offerings, BIC meals are required to meet the same federal nutritional guidelines as cafeteria breakfasts.

The Food Research and Action Center (FRAC), a national advocate for the SBP in general and BIC in particular, credits BIC for high rates of SBP participation in urban school districts like Detroit, Houston, Newark, San Antonio, Washington, D.C., and Providence (FRAC, 2012). There has been little research, however, on BIC's effects on breakfast program participation, academic or behavioral outcomes, or weight. One evaluation of a 2003-04 BIC pilot in upstate New York found SBP participation doubled after implementation of the program, and found modest improvements in attendance, behavior, and tardiness (Murphy, Drake, & Weineke, 2005). The study, however, lacked a control group and involved only a small number of schools. A recent working paper re-analyzing data from a U.S. Department of Agriculture experiment found that BIC had large positive effects on SBP participation, and increased the likelihood that students ate a "nutritionally substantive" breakfast by more than 10 percentage points (Schanzenbach & Zaki, 2014). The effects of BIC on meals participation were considerably larger than the offer of free breakfast alone.

Imberman and Kugler (2014) provide strong quasi-experimental evidence on the effects of offering breakfast in the classroom. That study examined the impact of BIC on math and reading achievement in 5th grade, and attendance and report card marks in grades 1-5. Their

[9] Not all schools in NYC have kitchen facilities for preparing hot meals. These schools would likely have served cold breakfasts prior to adopting BIC. Schools with kitchens may have offered cold items as menu options.

setting was an urban district that—like NYC—had previously offered breakfast free to all students. The district implemented BIC in 85 schools over a period of 11 weeks in 2009-10, which enabled the authors to contrast outcomes in early adopter schools (those implementing BIC before the test) with those in late adopting schools (implementing after the test). They found substantial intent-to-treat effects of BIC on reading and math achievement (0.10 s.d.), with larger effects for initially low-achieving students (0.13 – 0.14 s.d.), Hispanics (0.14 – 0.15 s.d.), and low-BMI students (0.26 s.d.). As many students in already participated in the SBP, the treatment effect of BIC on the treated in this district was potentially much higher. They found no impact of BIC on attendance rates or report card grades.

Interestingly, the achievement effects found in Imberman and Kugler did not vary with the amount of time students had been offered BIC. Thus, even schools that adopted BIC as little as one week prior to testing experienced gains in test performance. While seemingly implausible at first, their finding recalls Figlio and Winicki (2005), who found that increasing caloric content of lunches on test day can improve test performance. It also aligns with experimental evidence described in Section 2.1 on the short-run effects of breakfast consumption and content on cognitive performance. Imberman and Kugler's finding of no impact on grades but a large impact on test scores supports a short-run caloric effect and lack of a sustained, long-run impact on achievement, but the study's short duration makes it difficult to rule out long-run effects.

An unpublished study by Dotter (2012) used the introduction of BIC in San Diego over a 4-year period to estimate its effects on achievement in 2nd – 6th grade, attendance, and classroom behavior. Unlike NYC and the district in Imberman and Kugler (2014), San Diego previously offered universal free breakfasts only in schools with Provision 2 status under the

National School Lunch Act ("UFM schools").[10] All others offered breakfast free or at a reduced rate to subsidy-eligible students and at full price to other students. BIC in San Diego thus coincided with a shift to universal free breakfast in schools that were not already UFM, making it difficult to disentangle the BIC and price effects. Like Imberman and Kugler, Dotter found large effects of BIC on achievement (0.11 s.d. in reading and 0.15 s.d. in math), but only in schools that did not already offer free breakfast to all students. Thus, the effect should be interpreted as the combined effect of BIC and free breakfast. He found no effect on attendance, but large positive effects on teacher-reported classroom behavior, such as exhibiting "respect for people and property."

These two studies supply strong evidence on the academic impacts of BIC, and go far beyond what was previously available. However, they have several limitations. First, neither provided evidence of the program's effect on student weight, an important outstanding question in the literature. Second, both relied on relatively small samples of elementary schools. Imberman and Kugler's main estimates are for 5th grade only in approximately 85 treatment and 19 control schools; Dotter looked at a broader range of grade levels, but a smaller number of schools (45 treatment and 22 control). His sample of non-UFM schools—where the only significant effects were found—was smaller (19 treatment and 16 control). It is plausible there are heterogeneous effects of BIC due to differences in prior participation in the SBP and the importance of stigma. Third, only Dotter is able to say much about long-run effects, up to four years after the first BIC implementation. Imberman and Kugler provide a clean estimate of the short-run impact of BIC, but their results may say more about calorie

[10] Under Provision 2, a school may certify children as eligible for free or reduced-price meals for up to four consecutive years—without collecting annual data on eligibility—and provide meals free of charge to all students. The intent is to reduce the administrative burden on schools and parents related to proving income eligibility. For details, see: http://www.gpo.gov/fdsys/pkg/CFR-2012-title7-vol4/pdf/CFR-2012-title7-vol4-part245.pdf

intake and the short-term malleability of test performance than about the long-run consequences of adjusting children's eating habits. Our analysis improves on prior work by incorporating annual student-level measures of BMI and a larger sample of students and BIC schools at the elementary and middle school level.[11]

Three studies that we are aware of have looked at the relationship between BIC and calorie consumption or weight, although only one has a design that supports causal claims. Baxter et al. (2010) collected cross-sectional data on BMI, breakfast program participation, and energy intake (from researcher observations) for a sample of 4th grade students in 17 schools, seven of which had adopted BIC. They found BIC participation was significantly and positively related to BMI, with children in BIC consuming more calories at breakfast and having higher BMIs than children eating breakfast in the cafeteria. Van Wye et al. (2013) surveyed students in 9 BIC and 7 comparison schools in NYC and found students offered BIC were more likely to eat more than once in the morning, consuming 95 more calories on average than students in schools not offering BIC. Access to student-specific data on calories consumed is an obvious advantage of these studies, as is Baxter et al.'s direct observation of meal consumption. However, both were correlational with a small number of schools that did not address selection into BIC. In a recent paper, Schanzenbach and Zaki (2014) provide stronger evidence of the program's effects on breakfast consumption and obesity by re-analyzing data from an experiment conducted by the U.S. Department of Agriculture in the early 2000s (Bernstein et al., 2004). In the original experiment, treated schools offered universal free breakfast and could choose to serve it in the cafeteria or the classroom (BIC). In a comparison of BIC and control schools that did not offer free breakfast, the authors

[11] Some high schools in NYC have implemented BIC. However, as we explain in the next section, our BMI data on high school students and schools appears to be less reliable than our data for elementary and middle school. Hence our analysis in this paper is restricted to students in elementary and middle grades.

found large effects of BIC on participation, and a five percentage point increase in the likelihood of eating more than one breakfast, but modest effects on breakfast consumption, and no effect on BMI or nutrition. They conclude that—for most students—BIC changed the location and timing of breakfast rather than the propensity to consume it. Not surprisingly in light of this, they find BIC had no impact on achievement or behavior. While randomization of free breakfast is an important feature of this study, it is worth noting the decision to offer BIC was not random, making a comparison of BIC and other treated schools (offering free breakfast only) non-experimental. Further, the number of BIC schools (18) was small relative to the cafeteria group (61). The community context for schools in the USDA study was also quite different from ours (NYC).[12] Thus, there remain open questions about the efficacy of BIC in the context of universal free breakfast in the cafeteria – the context increasingly relevant for urban school districts nationwide.

II. DATA

A. OVERVIEW OF DATA SOURCES AND MEASURES

We draw on four primary data sources, all provided by the New York City Department of Education (NYCDOE) and its Office of School Food. The first is a database of BIC participation that includes start dates for schools that ever adopted BIC, and the extent of program coverage in the school (e.g., grades served and the number of BIC and total classrooms). The second is longitudinal school-level data on breakfast and lunch participation for all regular public schools that served elementary and/or middle grades between 2001-02 and 2011-12. This data provides annual counts of meals served, average

[12] The participating school districts included Boise, ID; Shelby Count, AL; Harrison County, MS; Phoenix, AZ; Santa Rosa, CA; and Wichita, KS.

daily attendance (ADA), and Provision 2 (UFM) status, and includes 1,000 to 1,100 schools enrolling 713,000 to 730,000 students, depending on the year. The third is administrative data for the universe of students in NYC public schools between 2006-07 and 2011-12, including basic demographics, educational needs and program participation (e.g., ELL and special education), standardized test scores in grades 3-8 in English Language Arts (ELA) and mathematics, and attendance rates. Finally, the fourth is annual student height and weight measurements collected through the city's *Fitnessgram* initiative; these are used to compute BMI and indicators of overweight and obesity, as described below. In all cases we exclude high schools, private, charter, prekindergarten, alternative, and other special schools or programs.[13]

NYC schools have conducted the *Fitnessgram* since 2005-06 as part of the district's standards-based physical education program.[14] *Fitnessgram* requires all schools to collect students' height and weight annually, and to assess students' aerobic fitness, muscle strength, endurance, and flexibility. At the end of the year, students receive a report that summarizes their performance and suggests ways for them to reach their "Healthy Fitness Zone," targets for better health based on their age and gender. While school coverage rates were lower in the early years of the *Fitnessgram*, by 2012 nearly 1,700 schools were participating each year, providing data on more than 860,000 students in all grades. We exclude students attending schools in which *Fitnessgram* coverage was lower than 50 percent, as measured students could be unrepresentative of the school.

[13] Conversations with the NYCDOE and the NYC Department of Health and Mental Health raised concerns about the quality of *Fitnessgram* data in high school. Whereas height and weight measurements in elementary and middle schools are taken by school staff (e.g., the school nurse or P.E. teacher), they are frequently self-reported in high school. Our concern about measurement error in the high school data led us to exclude these students from our analysis.
[14] See Rundle et al. (2012) and Elbel et al. (2013).

From the *Fitnessgram* we used students' weight (in pounds) and height (in inches) to compute BMI using the standard formula ($weight / height^2$)*703. Biologically implausible values—defined as more than 4 s.d. below or 5 s.d. above the mean for the students' gender and age in months—were set to missing. Using BMI in combination with the student's gender and age in months at the time of measurement, we used the CDC's 2000 BMI-for-age charts to classify children above the 95th percentile as obese.[15] (CDC percentiles are based on the national distribution of BMI in 2000). Though there is some debate in the public health literature over the best measure of adiposity in children (e.g., Cole et al., 2005; Mooney, Baecker, & Rundle, 2013), we use two measures in this analysis: BMI standardized by gender and age (z-BMI), and a 0-1 indicator for BMI above the obesity threshold.

Our achievement data tracks students longitudinally as they progress through school. For students in grades K-8, the data includes school of record (in October, March, and June), gender, race/ethnicity, age, eligibility for free or reduced price meals, recent immigrant status, days in attendance, and participation in other educational programs (e.g., special education and/or ELL). Attendance rates were calculated as the number of days present as a percentage of days enrolled. For students in grades 3-8, scale scores on the state ELA and mathematics tests were standardized to a mean zero, standard deviation one scale within grade, subject, and testing year.

B. BIC ADOPTION IN NEW YORK CITY

Figure 1 shows the cumulative number of NYC schools adopting BIC by month for the period 2007-08 to 2011-12. Though the NYCDOE supplies meals to public, charter, and private schools, we focus here on regular public schools serving students in grades K-8. We

[15] See http://www.cdc.gov/growthcharts/clinical_charts.htm. The most recent growth charts are for 2000-01.

also restrict our analysis to elementary and middle schools, which make up the large majority of BIC adopters. As seen in Figure 1, the largest number of BIC adoptions occurred in early 2010-11, although a significant number of schools began offering BIC in 2008-09 and 2009-10. By the end of 2011-12, a total of 195 elementary and middle schools had adopted the program, with an average daily participation of more than 30,000 students.[16] It is worth noting that not all schools adopted BIC at the start of the school year; many implemented mid-year.

Not all schools adopting BIC did so school-wide. In some cases BIC was targeted to specific grades or a subset of classrooms within the school. Unfortunately, data linking specific students or classes to BIC is unavailable.[17] Therefore we used information on the number of BIC and total classrooms, grades served, and school grade span to create three indicators of BIC participation corresponding with the degree of "coverage" within a school. The first indicator is equal to one for schools offering BIC at all (and zero otherwise). The second is equal to one for schools offering BIC in at least 25% of classrooms, but not school-wide, which eliminates schools piloting the program or offering BIC to a small number of students. Finally, the third is equal to one for schools offering BIC school-wide ("full school").[18] The bars in Figure 1 show the number of schools in each month that adopted BIC according to these definitions. While the majority of schools fall into the first category of coverage, by the end of 2011-12, 62 elementary and middle schools offered BIC to at least

[16] Including regular high schools, the total number of BIC schools in 2011-12 was 279 schools with an average daily BIC participation of 36,000. Adding private, charter, pre-kindergarten, alternative, and special education schools the total number of schools was 348 with an average daily participation of 41,500.
[17] BIC adoption is based on data collected by the NYC Office of School Food in November 2009, March 2011, and October 2012. Each wave provided contemporaneous information about BIC participation and start date. We use information from all three waves to construct our treatment variables.
[18] We are less confident in data available on the specific grades offered BIC in each school, where applicable, or in the exact percentage of classrooms offering BIC. This led us to the broader classification described here. We have, however, estimated models using these alternative measures of treatment (available in the online appendix).

25% of classrooms, and 23 offered it school-wide.

Table 1 reports mean characteristics of four groups of schools serving elementary and middle grades: those that never adopted BIC, those that adopted BIC any time prior to June 30, 2012, those that adopted BIC prior to this date and offered it in at least 25% of classrooms, and those that adopted BIC school-wide prior to this date. (School characteristics are measured as of 2006-07, the year before any school began BIC, and the latter three groups are not mutually exclusive). By a number of measures, BIC schools were more disadvantaged than those that never adopted the program. For example, they enrolled a greater percentage of students eligible for free meals (74.1% versus 67.3%) and had higher concentrations of black, Hispanic and ELL students. Standardized test scores were lower on average in BIC schools, both in reading (-0.13 s.d.) and in math (-0.16 s.d.), and were lower still in schools with more extensive BIC coverage. Schools in all five boroughs adopted BIC, though they were over-represented in the Bronx. Interestingly, average daily participation in the breakfast program was comparably low in 2006-07 in schools that adopted BIC versus those that did not (23.3% vs. 24.5%). Finally, students in BIC schools had higher BMI prior to adoption, on average, than those attending non-BIC schools, especially in schools with greater BIC coverage. Roughly one in four students in schools that adopted BIC school-wide were classified as obese. The overall obesity rate in NYC schools is high, however, with more than 20 percent of students in non-BIC schools considered obese.

III. EMPIRICAL STRATEGY

Our identification strategy is a difference-in-difference design using school fixed effects and student-level covariates to contrast observationally similar students in schools that did and did not adopt BIC, before and after implementation. This approach allows for the possibility of non-random selection of schools into the program on the basis of fixed, unobserved characteristics that are also correlated with the outcome of interest (e.g., obesity, meals program participation). Unbiased estimates of causal effects requires the absence of unobserved, time-varying effects that coincide with the adoption of BIC. We later provide graphical evidence that BIC and non-BIC schools were on similar trajectories prior to schools' adoption of BIC.

Each of our student-level models takes the following form for outcome Y_{igst} (BMI, obesity, math score, reading score, attendance) for student *i* in grade *g*, school *s*, and year *t*:

$$(1) \qquad Y_{igst} = \delta * BIC_{ist} + \beta' \boldsymbol{X}_{it} + \alpha_t + \gamma_s + u_{it}$$

$\boldsymbol{X}_{it}$ is a vector of student covariates potentially related to both the outcome *Y* and school-level adoption of BIC. These include eligibility for free or reduced price meals, race/ethnicity, limited English proficiency, special education status, age in months (in the *Fitnessgram* models only, as of the date of BMI measurement), and lagged math or reading scores (in the achievement models).[19] γ_s and α_t are school and year effects, respectively, and u_{it} is a student-year error term. BIC_{ist} is defined below. Standard errors are adjusted for clustering at the school level. Given biological and growth differences between boys and girls, and the possibility that boys and girls of different ages may respond differently to food interventions, BMI models are estimated separately by gender, and all models are estimated separately by school level (elementary or middle).

[19] A single variable in the model indicates whether the student is eligible for free or reduced price meals, or whether the student is enrolled in a UFM school. In cases where eligibility status is missing, this variable is equal to zero. We include an additional indicator variable equal to one for students with missing eligibility information.

Our model for meals program participation is similar to (1), but estimated using annual data at the school and meal type level, with separate models for breakfast and lunch:

$$(2) \qquad \left(\frac{ADP_{mst}}{ADA_{st}} * 100\right) = \delta * BIC_{st} + \beta' \boldsymbol{W}_{st} + \alpha_t + \gamma_s + \upsilon_{st}$$

In (2), the dependent variable is the average daily participation rate for meal *m* (breakfast or lunch) in school *s* and year *t*, defined as the average number of *m* meals served per school day (ADP_m) divided by average daily attendance (*ADA*) and multiplied by 100. This can be interpreted as the percent of students in attendance who take a meal *m* on an average day in school *s* in year *t*. α_t and γ_s are defined as in (1), and $\boldsymbol{W}_{st}$ is a vector of school-level covariates, including total enrollment, percent female, percent by race/ethnicity, percent ELL, percent in special education, and percent eligible for free or reduced price meals. The school models are also estimated separately by level (elementary or middle) and standard errors are adjusted for clustering by school. In alternative specifications of model (2), we add school-specific linear time trends to allow for differential trends over time in the outcomes.

BIC treatment is defined in two primary ways. The first is a simple indicator variable equal to one when student *i*'s school *s* adopted BIC prior to the date their outcome was measured in year *t* (e.g., *Fitnessgram* measurement or test date), and zero otherwise. As not all schools offered BIC school-wide, this is refined using the three increasingly stringent definitions of BIC coverage described earlier. These are the offer of BIC to any classroom in the school; to at least 25% of the school’s classrooms; and school-wide. The second primary definition of treatment is student-specific, with BIC_{ist} equal to the cumulative number of days, in hundreds, that student *i* has been attending *any* school offering BIC prior to the date their outcome was measured in year *t*. This treatment is intended to capture heterogeneity in student exposure to BIC, and—like the school-level treatment—is implemented using the three increasingly stringent thresholds of BIC coverage. To the extent BIC takes time to have an effect on BMI and/or achievement, this specification may be more appropriate.[20]

BIC is the *offer* of breakfast in the classroom, and thus estimates from our student models should be interpreted as "intent-to-treat." In treated schools, all or at least a fraction of students is offered BIC in their classroom. Students are not required to participate, and they may refuse the free breakfast. There is sure to be some selection of students into BIC *within* treated schools. Moreover, treatment effects conceptually operate through at least four channels: (1) BIC encourages some students to participate in the SBP who previously did not; (2) BIC alters the content, timing, and location of breakfast for students who already participated; (3) BIC affects the classroom climate for all students in BIC classrooms, regardless of whether they participate; and (4) BIC affects perceptions of the school meals program, even for students in classrooms not offering BIC, perhaps through a change in stigma. (For an example of the latter type of effect, see Leos-Urbel et al., 2013). Our estimates should be viewed as the net effect of offering BIC for students in schools that choose to adopt it.

IV. RESULTS

A. THE IMPACT OF BIC ON SCHOOL MEALS PROGRAM PARTICIPATION

[20] We have experimented with numerous variations on these two treatment definitions. These alternate measures are described later in the paper, where appropriate. Model estimates from these alternative approaches are available in the online appendix.

Figure 2 shows long-run trends in average daily participation in meals programs in BIC and non-BIC schools during our study period. For BIC schools the time series is centered at t=0, the year prior to the school's adoption of BIC, indicated with a dotted line. For schools that never adopted BIC, t=0 corresponds to the 2007-08 school year, the year before the modal school adopted BIC. (The time pattern of average daily participation for non-adopters is not sensitive to this choice, since their line passes smoothly through the t=0 point). The level and trend in breakfast participation rates were remarkably similar between BIC and non-BIC schools prior to schools' adoption of the program. In both cases, breakfast participation averaged 21 to 22 percent of ADA in the years leading up to BIC, increasing steadily at a rate of 1 percentage point per year. After BIC implementation, participation rates in BIC schools nearly doubled, on average, while those in non-BIC schools plateaued at 24-25 percent. Figure 2 represents an unbalanced panel; however, repeating the analysis with a (smaller) balanced panel of schools produces a nearly identical figure (provided in the online appendix).

By comparison, there were relatively small changes in average lunch program participation rates after BIC adoption. Prior to the introduction of BIC, lunch participation was consistently 2 to 3 points higher in BIC schools than non-BIC schools (75.5 vs. 78.5), which is unsurprising given BIC schools enrolled a larger share of students eligible for subsidized meals. After implementation, lunch participation rates were virtually unchanged for these two groups of schools.

Moving beyond descriptive changes, we estimated the regression model in (2) to estimate impacts of BIC adoption on average daily meal participation. All of these models include school fixed effects and covariates, such that coefficient estimates are identified off of changes within schools over time. The results are reported in Table 2. Each cell in this table is a coefficient and standard error estimate from a separate regression using the treatment definition shown in the row and the sample shown in the column. Rows (1)-(3) are impact estimates for breakfast participation and rows (4)-(5) are estimates for lunch participation.

The point estimates in Table 2 are consistent with the visual evidence presented in Figure 2. Across all schools serving elementary and middle grades, we find offering BIC increased SBP participation rates by 11.8 percentage points, on average, from a baseline 20.1 percent, a nearly 60 percent increase. Although the point estimates from the separate elementary and middle school regressions are identical at 13 percentage points, the effect size in middle school is proportionately larger, since these schools had lower baseline participation (12 percent versus 23.6 in elementary schools).[21] We also observe larger effects on meals served when BIC classroom coverage is higher. For example, the estimated impact on average daily breakfast participation is 21 to 25 percentage points when at least 25 percent of classrooms are offered BIC, and 29 to 32 percentage points when BIC is offered school-wide. (All estimated effects on breakfast participation in Table 2 are statistically significant at the 0.01 level or better). This finding provides support for our classifications of BIC coverage at the school level, and a strong "first stage" effect of BIC on program take-up.

In contrast, we find the offer of BIC had no significant impact on lunch participation rates. In all cases, the coefficient estimates for lunch participation in Table 2 are small (usually less than 1 percentage point) and are statistically insignificant. Taken together, there is no evidence to suggest BIC crowded out lunch program participation or encouraged greater participation (say, by reducing stigma associated with subsidized meals).

[21] In Table 2, the count of schools appearing in the "all schools" regressions is larger than the sum of schools appearing in the "elementary" and "middle school" only regressions, since the former includes schools serving *both* elementary and middle grades. Unfortunately, meals served data is not disaggregated by grades within schools.

Including school-specific linear time trends to the models in Table 2 has only modest effects on these estimated impacts. For example, among all schools, the effects on breakfast participation rates are 8.3, 17.2, and 26.4 percentage points for the three treatment intensities, respectively. All remain statistically significant at the 0.01 level. (Results are available in the online appendix).

B. THE IMPACT OF BIC ON BMI AND OBESITY

Estimates of the impact of BIC on student BMI and obesity are reported in Table 3. In this table, each cell reports the estimated BIC treatment coefficient and standard error from a separate regression. The regressions differ in their estimation sample (grades K-5 or 6-8; girls or boys), specification of the BIC treatment (pre-post indicator for school s, or cumulative days of exposure for student i), and minimum BIC coverage (any offer of BIC; at least 25% classroom coverage; full school BIC). Impact estimates for BMI are given in panel A, while estimates for obesity are in panel B. Results in later subsections are organized in an analogous manner.

We find no evidence that the offer of BIC increased BMI or the prevalence of obesity. The point estimates in Table 3 tend negative, which if significant would indicate that students have lower BMI and lower rates of obesity when their school offers BIC than observationally similar students attending the same schools when not offering BIC. All of the effect sizes are small, however. The only statistically significant effect we observe is for middle school boys in schools offering BIC school-wide. Here we find BMI is 0.06 standard deviations lower, on average, when the student's school offers BIC school-wide than when it does not offer BIC at all ($p<0.05$). The rate of obesity among these students is roughly 1.4 percentage points lower, on a baseline rate of 22 percent (the obesity effect is not statistically significant). The single statistically significant coefficient in Table 3 should be viewed with caution, however. Given the large sample size and number of different treatment effect definitions and subsamples, one would expect to see some statistically significant effects, even if by chance.

In general, the estimated effects of BIC on BMI and obesity are larger in schools with greater BIC coverage, as would be predicted if a treatment effect were present and BIC coverage reflected the likelihood of being treated. This pattern is not always consistent, however, and we cannot generally reject the hypothesis that the effects are the same across treatment definitions. Interestingly, when BIC treatment is measured using cumulative days of student exposure, the point estimates are sometimes positive—though never significant—suggesting prolonged BIC exposure could be associated with higher BMI.[22]

As noted, we experimented with numerous alternative specifications of the BIC treatment variable.[23] For example, we set the cumulative days of exposure to zero if the student was not currently in a BIC school; in most cases these point estimates were smaller in absolute value than those in Table 3. Alternatively, we defined cumulative days of exposure as the number of treated days prior to measurement in year t only, with a separate dummy variable indicating BIC treatment in prior years. The point estimates were again closer to zero than in Table 3. Finally, we estimated models in which the treatment variables for the three levels of classroom coverage were jointly included in the model as mutually exclusive categories. None of the results were materially different from those in Table 3.

C. The Impact of BIC on Student Achievement

[22] For example, among middle school students with strictly positive days offered BIC school-wide, the mean days exposed is 125 with s.d. 112. Using our point estimates, a female middle school student 1 s.d. above the mean in cumulative exposure would be predicted to have a 0.039 s.d. higher BMI than a similar student with no exposure, and a 1.8 percentage point higher rate of obesity. At the elementary level, the predicted effect would go in the other direction, with greater exposure associated with lower BMI. This example is only illustrative, however, since the effect is not statistically significant.

[23] Results using these alternative specifications are available in the online appendix.

Table 4 reports our estimates of the impact of BIC on student achievement in ELA and mathematics. As in Table 3, each cell is the estimated treatment effect from a separate regression, with comparable estimation samples, treatment variable specifications, and BIC coverage thresholds. The main differences are that the elementary school models use only grades 4-5, since testing begins in 3rd grade and lagged achievement is included as a covariate, and boys and girls are combined in a pooled model. (Separate estimates by gender do not appreciably differ from those presented here).

We find no consistent evidence of an impact of BIC on achievement in either subject. Most point estimates are small in absolute value and vary in sign, with ELA estimates mostly negative and math estimates mixed. In ELA, we observe a statistically significant and negative effect of -0.020 s.d. ($p<0.05$) for middle school students attending schools with at least 25% classroom coverage, an effect that is larger with prolonged exposure to BIC (-0.005 s.d. per 100 days; $p<0.05$). In math, the only statistically significant effect we observe is for middle schoolers attending schools with at least 25% classrooms coverage, a positive 0.008 s.d. per 100 days ($p<0.05$). The point estimates are larger for students attending schools that adopted BIC school-wide, but are not significant. Again, with a large sample and multiple models, it is not surprising to find some statistical significance. On balance, we see no strong evidence of an impact of BIC on academic performance.

As was true for the BMI and obesity models, the estimated effects of BIC on achievement tend to be larger in schools with greater BIC coverage, although this pattern is not consistent, and we cannot reject the hypothesis that the effects are the same across treatment intensities. When BIC treatment is measured using cumulative days of student exposure, the results suggest that prolonged BIC participation could be associated with lower ELA scores and higher math scores. Here again the cumulative effects would be small.[24] Indeed, all of the achievement effects we observe are considerably smaller than those estimated in prior quasi-experimental studies (Imberman & Kugler, 2014; Dotter, 2012). In the concluding section of the paper, we consider several potential explanations for the divergent findings.

We experimented with the same alternative specifications of the BIC treatment variable for our achievement models as we did for BMI and obesity. In no case were the results materially different.[25] Additionally, because the estimation sample differs for the BMI/obesity and achievement outcomes, we estimated both sets of models with a fixed, identical sample of students with sufficient data to be included in all models.[26] Again, the results were qualitatively very similar.

D. THE IMPACT OF BIC ON ATTENDANCE

Table 5 reports estimates of the impact of BIC on attendance rates, measured as the number of days present as a percent of days enrolled. As in earlier tables, each cell is the estimated treatment effect from a separate regression, with comparable estimation samples, treatment variable specifications, and coverage thresholds. For the attendance outcome, the elementary school models include all grades K-5 (not just the tested sample). The middle school models continue to use grades 6-8. Again, boys and girls are combined.

In this case the estimated effects in middle school are positive, and some are statistically significant ($p<0.05$). Students in middle schools offering BIC had 0.3 to 0.4 percentage point higher attendance rates when BIC was offered in their school, depending on the extent of

[24] For example, a middle school student 1 s.d. above the mean in cumulative days in a school with at least 25% classroom coverage would be predicted to have 0.006 s.d. lower ELA scores and 0.009 s.d. higher math scores
[25] Results using these alternative specifications are available in the online appendix.
[26] For instance, students in grades K-3 contribute to the BMI/obesity and attendance estimates in Tables 3 and 5 but not to the achievement estimates in Table 4, since they lack a current and lagged test score. Moreover, some students with test scores did not have *Fitnessgram* data and thus did not contribute to the BMI estimates.

BIC classroom coverage. In all cases, the estimated effect sizes are very small. In elementary school, attendance rates are already high—about 92 percent in schools that ever adopted BIC—and in middle school about four points lower, on average (88 percent). Assuming a 180-day school year, a 0.50 percentage point increase in attendance translates into 0.9 school days. Thus, the average effect found here amounts to about one quarter to less than one full school day.

In complementary work (not shown here), we looked at the potential "socializing effects" of BIC by testing for effects on responses of middle school students to NYC's School Environment Survey. This survey aims to capture student attitudes toward their school, classroom, and teachers, with items such as "I feel welcome in my school," "Most of the adults I see at school every day know my name or who I am," "I am safe in my classes," and so on. We did not find any consistent effects of BIC on responses to any of these survey items.

V. DISCUSSION

BIC has been widely adopted by school districts across the United States, with the goal of increasing SBP participation and ensuring no child starts the school day hungry. Advocates argue moving breakfast from the cafeteria to the classroom will provide myriad other benefits as well, including improved attendance, engagement, and academic performance. One recent study supports the latter claim, finding a substantial impact on math and reading performance (Imberman & Kugler, 2014). Whether these effects represent short-run boosts in test scores or sustained, long-run impacts on academics remains unclear.

At the same time, others have warned that BIC will have deleterious effects on students' weight, increasing BMI and obesity, as participants consume more daily calories or less nutritious food than they otherwise would. BIC expansion in NYC was temporarily suspended over this very claim. The evidence base on BIC's impact on obesity, however, is thin. Our analysis using longitudinal *Fitnessgram* measures of student BMI indicates these fears are largely unwarranted. We find no evidence BIC increased BMI or the incidence of obesity among students attending schools in New York City offering the program. Nearly all of our point estimates suggest lower average body mass in schools when students are offered BIC, though these effects are small and not statistically different from zero.

At the same time, our study finds large positive effects of BIC on SBP participation, an effect that did not come at the expense of lower lunch participation. We find no evidence of an impact on reading and math achievement in schools that adopted BIC. That class time devoted to BIC did not adversely affect achievement is encouraging. But in no case do our estimates suggest the positive effects found in prior quasi-experimental studies. They do, however, align with a recent re-analysis of experimental data showing BIC has small net effects on breakfast consumption and in turn no effect on achievement.

There are a number of reasons why our achievement effects may depart from those in earlier quasi-experimental studies. First, the "first stage" impact of BIC on program participation may have been weaker in NYC than in other settings. Table 2 revealed a substantial increase in SBP take-up in BIC schools, but this increase was smaller than that observed in San Diego (Dotter, 2012). In that study, SBP participation in BIC schools exceeded 90 percent, well above what we observe in NYC.[27] As expected, we did not observe as large an impact on school-wide participation in NYC schools that adopted BIC in a subset of classrooms, which may contribute to our overall null finding on achievement. However, we also found no effects in schools that offered BIC school-wide, where the impact on participation was much larger. Understanding variability in the effects of BIC on take-up across contexts will be an important question for future research. Second, NYC was already offering free breakfast to students citywide prior to BIC (Leos-Urbel et al., 2013). Dotter (2012) found effects on achievement in San Diego schools, but only in those that did not already offer universal free breakfast. This is consistent with our findings, and may suggest few added benefits of BIC—at least for achievement—beyond those provided by free breakfast.

While our study improves on existing work in a number of ways, it has several limitations. Imprecise treatment measures at the classroom level led us to three relatively broad

[27] Imberman and Kugler (2014) do not estimate the impact of BIC on breakfast participation in their district but highlight a pilot study that documented 80 percent participation in BIC schools (versus 41 percent in all other schools). Both rates are higher than those observed in NYC.

categories of BIC coverage aiming to capture the offer of BIC within a school. Our approach is validated by an increasingly strong relationship with SBP participation post-implementation, but could be improved with classroom- or individual-specific meals data. In ongoing work, we are using newly-acquired point-of-sale (POS) data provided by the NYC Office of School Food to track individual daily student breakfast participation for a subset of schools.

Despite these limitations, our study is one of the first to examine the effects of offering BIC on BMI and obesity. It uses annual student-level data on obesity from New York City, the largest school district in the country, where nearly 300 schools adopted BIC by 2011-12 (and roughly 200 schools serving grades K-8 were used in our models). This data includes observations on students as many as four years post-BIC implementation, allowing us to potentially detect long-run effects. Breakfast in the Classroom has received considerable scrutiny and media attention in NYC, and school districts nationwide have followed its roll-out closely. Our investigation of the impact of BIC yields evidence of significant increases in SBP participation and (small) improvements in middle school attendance, with no effect on lunch participation, academic performance, or any weight outcome, including BMI and obesity. Thus the modest positive impacts of BIC do not come at the cost of worsening childhood obesity. School districts concerned about hunger and food insecurity among their most vulnerable students might do well to consider Breakfast in the Classroom to address these issues.

References

Bartfeld, J., & Kim, M. 2010. Participation in the School Breakfast Program: New evidence from the ECLS-K. *Social Service Review, 84,* 541–62.

Basch, C.E. 2011. Breakfast and the achievement gap among urban minority youth. *Journal of School Health, 81,* 635–40.

Baxter, S.D., Hardin, J.W., Guinn, C.H., Royer, J.A., Mackelprang, A.J. & Devlin, C.M. 2010. Children's body mass index, participation in school meals, and observed energy intake at school meals. *International Journal of Behavioral Nutrition and Physical Activity, 7,* 1–8.

Bernstein, L.S., McLaughlin, J.E., Crepinsek, M.K., Daft, L.M. & Murphy, J.M. 2004. Evaluation of the School Breakfast Program pilot project: Final report, Nutrition Assistance Program Report Series, No. CN-04-SBP, Project Officer: Anita Singh. U.S. Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition, and Evaluation, Alexandria, VA.

Bhattacharya, J., Currie, J. & Haider, S.J. 2006. Breakfast of champions? The School Breakfast Program and the nutrition of children and families. *Journal of Human Resources, 41,* 445–66.

Briefel, R., Murphy, J.M., Kung, S., & Devaney, B. 1999. Universal-free school breakfast program evaluation design project: Review of literature on breakfast and learning. Princeton, NJ: Mathematica Policy Research.

Cole, T.J., Faith, M.S., Pietrobelli, A., & Heo, M. 2005. What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? *European Journal of Clinical Nutrition, 59,* 419–25.

Dahl, M.W., & Scholz, J.K. 2011. The National School Lunch Program and School Breakfast Program: Evidence on participation and noncompliance." Working Paper, University of Wisconsin Madison. Retrieved from http://www.econ.wisc.edu/~scholz/Research/Lunch.pdf.

Dotter, D. 2012. Breakfast at the desk: The impact of universal breakfast programs on academic performance. Working Paper, University of California San Diego Department of Economics. Retrieved from http://econweb.ucsd.edu/~ddotter/pdfs/Dotter_JMP_Manuscript.pdf

Dunifon, R. & Kowaleski-Jones, L. 2003. The influences of participation in the National School Lunch Program and food insecurity on child well-being. *Social Service Review, 77,* 72–92.

Elbel, B., Corcoran, S.P., & Schwartz, A.E. 2013. Neighborhoods, schools and obesity in New York City: The potential for place-based approaches to reduce childhood obesity. Working Paper, New York University Institute for Education and Social Policy.

Figlio, D.N. & Winicki, J. 2005. Food for thought: The effects of school accountability plans on school nutrition. *Journal of Public Economics 89,* 381–94.

FRAC. 2012. School breakfast scorecard: School year 2010-2011.

Hinrichs, P. 2010. The effects of the National School Lunch Program on education and health. *Journal of Policy Analysis and Management, 29,* 479–505.

Hoyland, A., Dye, L., & Lawton, C.L. 2009. A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. *Nutrition Research Reviews, 22,* 220–43.

Imberman, S.A., & Kugler, A.D. 2014. The effect of providing breakfast in class on student performance. *Journal of Policy Analysis and Management, 33,* 669–99.

Leos-Urbel, J. Schwartz, A.E., Weinstein, M., & Corcoran, S.P. 2013. Not just for poor kids: The impact of universal free school breakfast on meal participation and student outcomes. *Economics of Education Review, 36,* 88–107.

McEwan, P.J. 2013. The impact of Chile's school feeding program on education outcomes. *Economics of Education Review, 32,* 122–39.

Millimet, D.L., Tchernis, R., & Husain, M. 2010. School nutrition programs and the incidence of childhood obesity. *Journal of Human Resources, 45,* 640–54.

Mooney, S.J., Baecker, A., & Rundle, A.G. 2013. Comparison of anthropometric and body composition measures as predictors of components of the metabolic syndrome in a clinical setting. *Obesity Research & Clinical Practice, 7,* e55–e66.

Murphy, J.M., Drake, J.E., & Weineke, K.M. 2005. Academics & breakfast connection pilot: Final report on New York's classroom breakfast project. Albany, NY. Retrieved from http://hungersolutionsny.org/documents/FinalABCupdated.pdf

Pollitt, E., & Mathews, R. 1998. Breakfast and cognition: An integrative summary. *The American Journal of Clinical Nutrition, 67,* 804S–813S.

Ponza, M. 1999. Universal-free school breakfast program evaluation design project: Final evaluation design. Princeton, NJ: Mathematica Policy Research. Retrieved from http://www.fns.usda.gov/ora/menu/DemoProjects/sbppilot/SBPdesign.PDF.

Poppendieck, J. 2010. *Free for all: Fixing school food in America.* Berkeley: University of California Press.

Rampersaud, G.C., Pereira, M.A., Girard, B.L., Adams, J. & Metzl, J.D. 2005. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *Journal of the American Dietetic Association, 105,* 743–60.

Rundle, A., Richards, C., Bader, M.D.M., Schwartz-Soicher, O., Lee, K.K., Quinn, J., & Lovasi, G.S. 2012. Individual- and school-level sociodemographic predictors of obesity among New York City public school children. *American Journal of Epidemiology, 176,* 986–94.

Schanzenbach, D.W. 2009. Do school lunches contribute to childhood obesity? *Journal of Human Resources 44,* 684–709.

Schanzenbach, D.W. & Zaki, M. 2014. Expanding the School Breakfast Program: Impacts on children's consumption, nutrition and health. National Bureau of Economic Research Working Paper No. 20308.

Simeon, D.T., & Grantham-McGregor, S. 1989. Effects of missing breakfast on the cognitive functions of school children of differing nutritional status. *American Journal of Clinical Nutrition, 49,* 646–53.

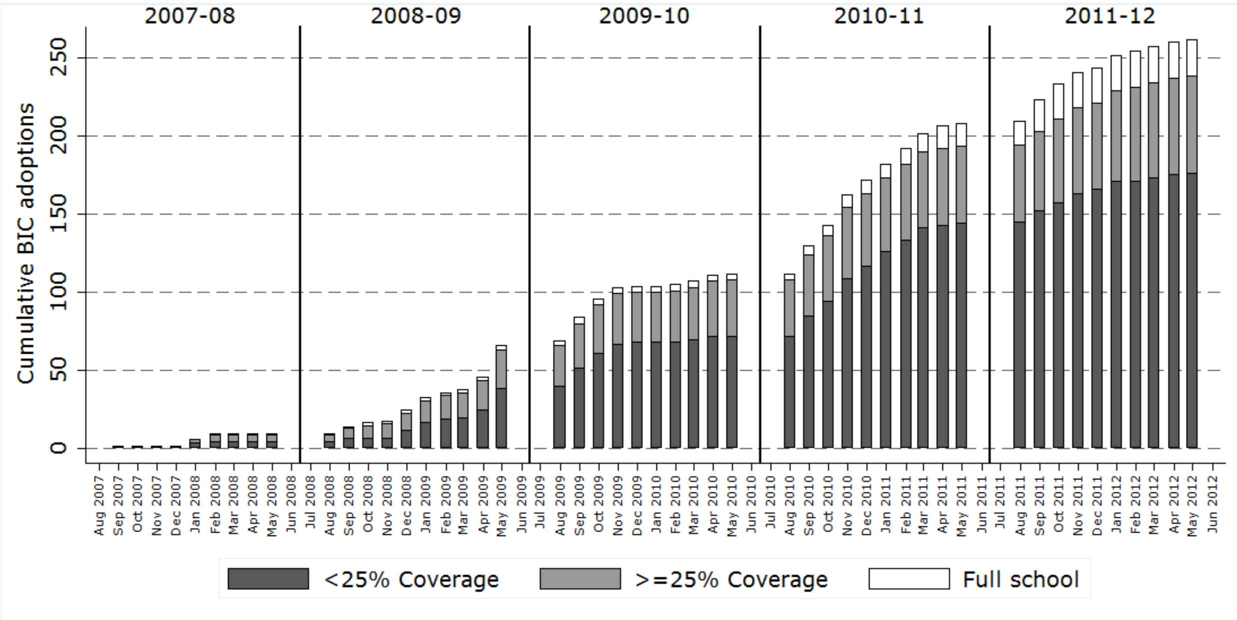
Vaisman, N., Akivis, A., Vakil E., & Voet, H. 1996. Effect of breakfast timing on the cognitive functions of elementary school students. *Archives of Pediatrics & Adolescent Medicine 150,* 1089–92.

Van Wye, G., Seoh, H., Adjoian, T., and Dowell, D. 2013. Evaluation of the New York City breakfast in the classroom program. *American Journal of Public Health, 103,* e59–e64.

Wesnes, K.A., Pincock, C., Richardson, D., Helm, G. & Hails, S. 2003. Breakfast reduces declines in attention and memory over the morning in schoolchildren. *Appetite 41,* 329–31.

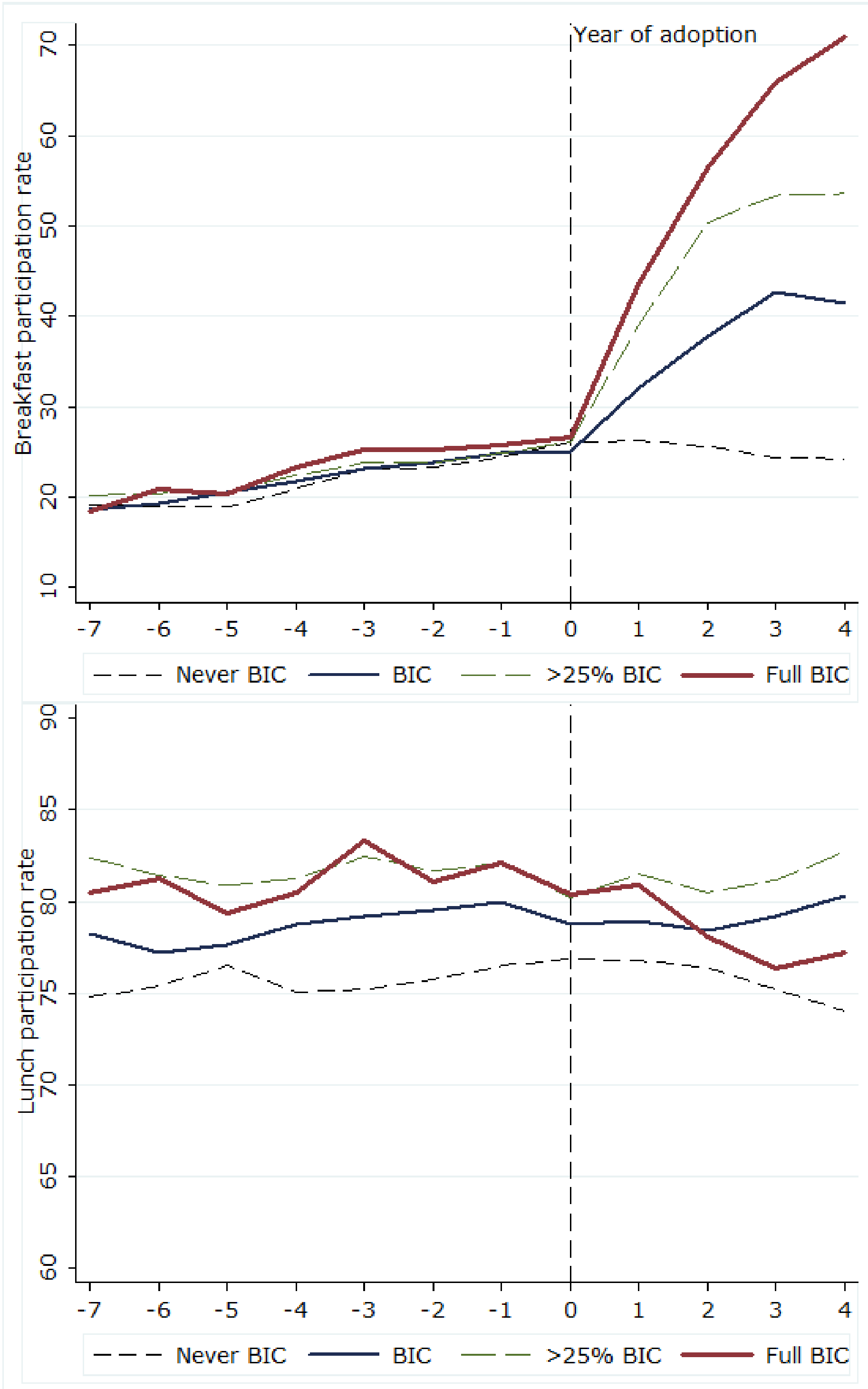
Wyon, D.P., Abrahamsson, L., Järtelius, M., & Fletcher, R.G. 1997. An experimental study of the effects of energy intake at breakfast on the test performance of 10-year-old children in school. *International Journal of Food Sciences and Nutrition, 48,* 5–12.

Figure 1: Cumulative Breakfast in the Classroom Adoptions by Month, New York City



Notes: reflects all schools adopting BIC prior to June 30, 2012 that offered BIC to any of the grades K-8. Only regular public schools are included; private, charter, alternative, and special education (District 75) schools are excluded, as are suspension or other special programs.

Figure 2: Mean Annual Breakfast and Lunch Participation Rates: Elementary and Middle Schools



Notes: uses an unbalanced panel of elementary and middle schools. For schools adopting BIC, year zero is the school year prior to adopting BIC. For schools never adopting BIC, year zero is the 2007-08 school year (the modal year of BIC adoption was 2008-09).

Table 1: Mean school characteristics by BIC adoption status and classroom coverage, baseline

	Never BIC	Ever BIC	Ever BIC w/>=25% coverage	Ever full school BIC
Breakfast participation rate	24.5	23.3	23.9	24.6
Lunch participation rate	76.5	79.7	82.6	82.4
BMI z-score	0.008	0.082	0.102	0.147
Percent obese	20.8	22.5	23.7	24.9
Reading z-score (grades 3-8)	0.017	-0.128	-0.258	-0.283
Math z-score (grades 3-8)	0.002	-0.158	-0.292	-0.310
Attendance rate	92.1	91.1	90.1	91.2
Percent eligible for free lunch	67.3	74.1	81.4	80.6
Percent ELL	11.7	12.8	12.7	14.5
Percent special education	13.9	14.6	15.4	17.1
Percent Asian	12.4	8.3	3.7	4.8
Percent black	33.5	37.1	40.4	34.6
Percent Hispanic	38.5	43.9	51.5	55.9
Percent white	14.7	9.7	3.3	3.5
Percent male	50.7	50.9	50.1	50.0
Percent enrollment grades K-5	60.1	58.9	61.3	65.1
Percent in Brooklyn	33.2	28.5	23.3	7.9
Percent in Manhattan	17.3	20.6	25.9	42.1
Percent in Queens	24.3	16.7	7.8	10.5
Percent in Staten Island	4.8	4.3	0.0	0.0
Percent in Bronx	20.3	29.9	43.1	39.5
Percent UFM school	45.1	42.5	45.6	45.9
School starting time	8:20 a.m.	8:19 a.m.	8:21 a.m.	8:19 a.m.
Total enrollment	657	724	683	660
N (observed in 2007)	807	281	116	38

Notes: only regular public schools serving any of the elementary and middle grades are included in the above. All means are for the 2006-07 academic year, and thus are prior to schools' adoption of BIC. "Never BIC" refers to schools that had not adopted BIC as of June 30, 2012. "Ever BIC" refers to any school that adopted BIC prior to June 30, 2012. "Ever BIC with >=25% Coverage" refers to any school that adopted BIC prior to June 30, 2012 and offered BIC to at least 25% of classrooms. "Ever Full BIC" refers to any school that adopted BIC school-wide prior to June 30, 2012. In the few cases where BIC coverage changed over time, we classified schools according to their highest extent of coverage.

Table 2: Impact of BIC adoption on meals program participation, 2001 – 2012

	All schools	Elementary	Middle
Breakfast:			
(1) Post BIC adoption	0.118***	0.130***	0.130***
	(0.009)	(0.012)	(0.020)
(2) Post BIC adoption: school with >25% coverage	0.211***	0.231***	0.251***
	(0.016)	(0.020)	(0.031)
(3) Post BIC adoption: full school	0.290***	0.319***	0.319***
	(0.032)	(0.044)	(0.032)
Lunch:			
(4) Post BIC adoption	-0.001	0.008	-0.014
	(0.005)	(0.005)	(0.014)
(5) Post BIC adoption: school with >25% coverage	-0.008	0.007	-0.014
	(0.008)	(0.007)	(0.020)
(6) Post BIC adoption: full school	-0.005	-0.002	0.048
	(0.018)	(0.018)	(0.048)
N – breakfast (school x year)	12,407	7,833	2,598
Mean breakfast participation pre-2008	0.201	0.236	0.120
N – lunch (school x year)	12,062	7,518	2,565
Mean lunch participation 2008	0.732	0.813	0.629

Notes: each cell is a coefficient estimate from a separate regression model. In rows (1) and (4), the coefficient is for the "post BIC adoption" indicator equal to one in school-years where BIC was offered in the school. For rows (2) and (4), this indicator is equal to one only if BIC was offered to at least 25% of classrooms in the school. For rows (3) and (6), this indicator is equal to one only if BIC was offered school-wide. The columns represent subsamples: all schools, elementary schools only (including elementary/ middle combinations), and middle schools only (including middle/high combinations). The dependent variable is the annual breakfast or lunch participation rate for a given school and year, measured as average daily meals served divided by average daily attendance. Standard errors, robust to clustering within schools, are in parentheses (*** p<0.001, ** p<0.01, * p<0.05).

Table 3: Impact of BIC on obesity and BMI

	Grades K-5 Pre-post Female	Male	Grades 6-8 Pre-post Female	Male	Grades K-5 Cumulative days /100 Female	Male	Grades 6-8 Cumulative days /100 Female	Male
Panel A: Impact on z-BMI								
(1) Post BIC adoption	-0.0038	-0.0030	-0.0403	-0.0085	0.0049	0.0010	0.0075	0.0042
	(0.0119)	(0.0120)	(0.0295)	(0.0178)	(0.0045)	(0.0047)	(0.0055)	(0.0043)
(2) Post BIC adoption: school with >25% coverage	-0.0049	-0.0089	-0.0395	0.0075	-0.0018	-0.0072	0.0127	0.0018
	(0.0169)	(0.0161)	(0.0632)	(0.0195)	(0.0071)	(0.0074)	(0.0108)	(0.0054)
(3) Post BIC adoption: full school	-0.0192	-0.0113	0.0125	-0.0562*	-0.0251	-0.0235	0.0164	-0.0117
	(0.0323)	(0.0323)	(0.0185)	(0.0236)	(0.0165)	(0.0193)	(0.0109)	(0.0102)
Panel B: Impact on obesity								
(4) Post BIC adoption	-0.0012	-0.0001	-0.0134	-0.0047	0.0021	0.0020	0.0036	0.0013
	(0.0032)	(0.0036)	(0.0111)	(0.0066)	(0.0013)	(0.0014)	(0.0021)	(0.0016)
(5) Post BIC adoption: school with >25% coverage	0.0013	-0.0002	-0.0182	0.0021	0.0020	0.0006	0.0046	0.0005
	(0.0049)	(0.0050)	(0.0237)	(0.0070)	(0.0022)	(0.0022)	(0.0039)	(0.0020)
(6) Post BIC adoption: full school	0.0003	-0.0047	0.0109	-0.0144	-0.0029	-0.0041	0.0077	-0.0054
	(0.0093)	(0.0097)	(0.0063)	(0.0089)	(0.0060)	(0.0061)	(0.0042)	(0.0042)
Observations	1,059,207	1,072,262	488,283	491,805	1,059,207	1,072,262	488,283	491,805

Notes: Standard errors robust to clustering at the school level shown in parentheses (* $p<0.05$). Obese is defined as being above the 95th percentile nationally for one's gender and age in months, based on the 2000 CDC BMI-for-age charts. All models include student covariates, grade, school, and year effects. Covariates include age, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Age is measured in months at the time of the Fitnessgram measurements. We exclude charter school students, students attending citywide special education schools (District 75), students in schools where Fitnessgram coverage is less than 50 percent, and students with biologically implausible BMIs.

Table 4: Impact of BIC on ELA and math achievement

	Grades 4-5 Pre-post		Grades 6-8 Pre-post		Grades 4-5 Cumulative days		Grades 6-8 Cumulative days	
	ELA	Math	ELA	Math	ELA	Math	ELA	Math
(1) Post BIC adoption	-0.011 (0.008)	-0.005 (0.011)	-0.000 (0.008)	0.007 (0.011)	-0.003 (0.002)	-0.001 (0.004)	-0.002 (0.002)	0.005 (0.003)
(2) Post BIC adoption: school with >25% coverage	-0.021 (0.014)	-0.005 (0.018)	-0.020* (0.009)	0.005 (0.017)	-0.006 (0.003)	-0.001 (0.004)	-0.005* (0.002)	0.008* (0.004)
(3) Post BIC adoption: full school	-0.041 (0.027)	0.028 (0.037)	-0.015 (0.019)	-0.008 (0.034)	-0.007 (0.009)	0.014 (0.010)	-0.005 (0.004)	0.012 (0.009)
Observations	717,486	744,934	1,097,593	1,126,258	717,486	744,934	1,097,593	1,126,258

Notes: Standard errors robust to clustering at the school level shown in parentheses (* p<0.05). All Models control for lagged z-score, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Excludes charter school students and students attending citywide special education schools (District 75).

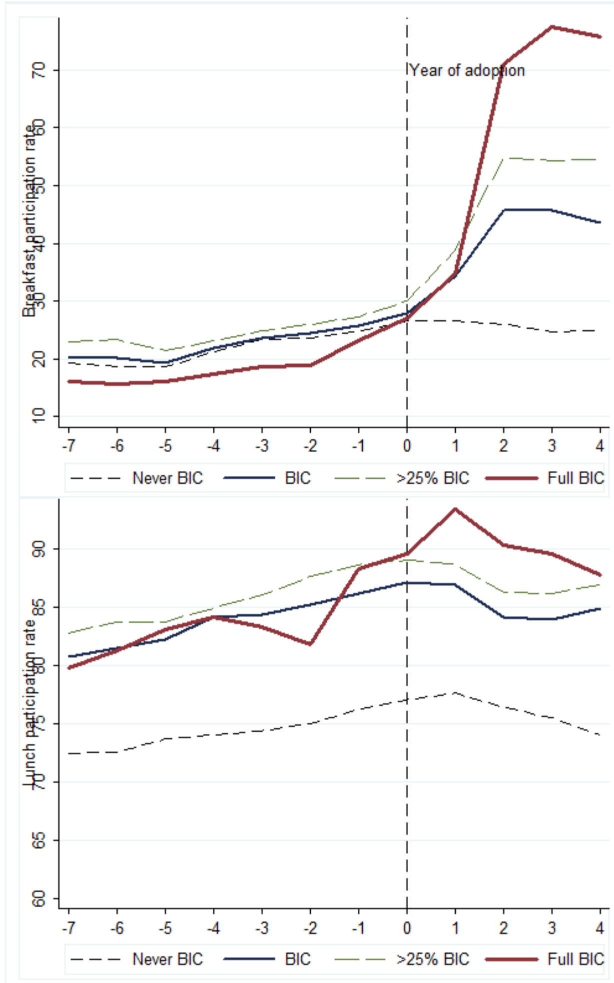
Table 5: Impact of BIC on attendance

	Pre-post		Cumulative days	
	Grade K-5	Grade 6-8	Grade K-5	Grade 6-8
(1) Post BIC adoption	<0.001 (0.001)	0.003* (0.001)	<0.001 (<0.001)	0.001* (0.000)
(2) Post BIC adoption: school with >25% coverage	0.001 (0.001)	0.004* (0.002)	<0.001 (<0.001)	0.001 (0.001)
(3) Post BIC adoption: full school	<0.001 (0.001)	0.004 (0.003)	<0.001 (0.001)	<0.001 (0.001)
Observations	2,496,321	1,228,769	2,496,321	1,228,769

Notes: Standard errors robust to clustering at the school level shown in parentheses (* p<0.05). All Models control for race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Excludes charter school students and students attending citywide special education schools (District 75).

SUPPLEMENTAL ONLINE APPENDIX

Appendix Figure A.1: Mean Annual Breakfast and Lunch Participation Rates: Balanced Panel of Elementary and Middle School



Notes: limiting the analysis to a balanced panel of schools from t-7 to t+4 reduces the number of schools to 569, 50, 30, and 6 in the four categories Never BIC, BIC, >25% BIC, Full BIC.

Appendix Table 1: Impact of BIC adoption on meals program participation, 2001 – 2012 – models using school specific linear time trends (compare to Table 2)

	All schools	Elementary	Middle
Breakfast:			
(1) Post BIC adoption	0.083***	0.094***	0.085***
	(0.008)	(0.011)	(0.019)
(2) Post BIC adoption: school with >25% coverage	0.172***	0.194***	0.191***
	(0.016)	(0.020)	(0.036)
(3) Post BIC adoption: full school	0.264***	0.271***	0.305***
	(0.033)	(0.042)	(0.038)
Lunch:			
(4) Post BIC adoption	-0.003	<0.001	-0.006
	(0.006)	(0.006)	(0.013)
(5) Post BIC adoption: school with >25% coverage	0.001	0.005	-0.017
	(0.009)	(0.010)	(0.019)
(6) Post BIC adoption: full school	0.005	-0.014	0.042
	(0.020)	(0.023)	(0.039)
N – breakfast (school x year)	12,407	7,833	2,598
Mean breakfast participation pre-2008	0.201	0.236	0.120
N – lunch (school x year)	12,062	7,518	2,565
Mean lunch participation 2008	0.732	0.813	0.629

Notes: each cell is a coefficient estimate from a separate regression model. In rows (1) and (4), the coefficient is for the "post BIC adoption" indicator equal to one in school-years where BIC was offered in the school. For rows (2) and (4), this indicator is equal to one only if BIC was offered to at least 25% of classrooms in the school. For rows (3) and (6), this indicator is equal to one only if BIC was offered school-wide. The columns represent subsamples: all schools, elementary schools only (including elementary/middle combinations), and middle schools only (including middle/high combinations). The dependent variable is the annual breakfast or lunch participation rate for a given school and year, measured as average daily meals served divided by average daily attendance. Standard errors, robust to clustering within schools, are in parentheses (*** p<0.001, ** p<0.01, * p<0.05).

Appendix Table 2: Impact of BIC on obesity and BMI – using grade-specific BIC treatment (compare to Table 3)

	Grades K-5 Pre-post Female	Male	Grades 6-8 Pre-post Female	Male	Grades K-5 Cumulative days Female	Male	Grades 6-8 Cumulative days Female	Male
Panel A: Impact on zBMI								
(1) Post BIC adoption	-0.0196	0.0013	-0.0573	-0.016	-0.0025	-0.0024	0.0023	-0.0027
	(0.0135)	(0.0129)	(0.0317)	(0.0180)	(0.0069)	(0.0075)	(0.0076)	(0.0054)
(2) Post BIC adoption: school with >25% coverage	-0.0197	0.0048	-0.064	-0.0052	-0.0126	-0.0123	0.0091	-0.0003
	(0.0182)	(0.0156)	(0.0688)	(0.0183)	(0.0088)	(0.0100)	(0.0136)	(0.0060)
(3) Post BIC adoption: full school	-0.0180	0.0106	0.0213	-0.0455*	-0.0427*	-0.0301	0.0196	-0.0061
	(0.0298)	(0.0269)	(0.0160)	(0.0223)	(0.0181)	(0.0234)	(0.0114)	(0.0118)
Panel B: Impact on obesity								
(4) Post BIC adoption	-0.0051	0.0002	-0.0203	-0.0069	-0.0001	0.0007	0.0005	-0.0011
	(0.0039)	(0.0039)	(0.0119)	(0.0068)	(0.0021)	(0.0022)	(0.0028)	(0.0020)
(5) Post BIC adoption: school with >25% coverage	-0.0035	0.002	-0.0283	-0.002	-0.0024	-0.0012	0.0018	-0.0003
	(0.0057)	(0.0045)	(0.0259)	(0.0069)	(0.0028)	(0.0029)	(0.0049)	(0.0022)
(6) Post BIC adoption: full school	-0.0062	-0.0008	0.0107	-0.0112	-0.0113	-0.0062	0.0075*	-0.0043
	(0.0100)	(0.0079)	(0.0059)	(0.0082)	(0.0058)	(0.0072)	(0.0035)	(0.0050)
Observations	1,059,213	1,072,266	1,059,213	1,072,266	1,059,213	1,072,266	1,059,213	1,072,266

Notes: Standard errors robust to clustering at the school level shown in parentheses (* p<0.05). Obese is defined as being above the 95th percentile nationally for one's gender and age in months, based on the 2000 CDC BMI-for-age charts. All models include student covariates, grade, school, and year effects. Covariates include age, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Age is measured in months at the time of the Fitnessgram measurements. We exclude charter school students, students attending citywide special education schools (District 75), students in schools where Fitnessgram coverage is less than 50 percent, and students with biologically implausible BMIs.

Appendix Table 3: Impact of BIC on ELA and math achievement – using grade-specific BIC treatment (compare to Table 4)

	Grades 4-5 Pre-post ELA	 Math	Grades 6-8 Pre-post ELA	 Math	Grades 4-5 Cumulative days ELA	 Math	Grades 6-8 Cumulative days ELA	 Math
(1) Post BIC adoption	-0.011 (0.008)	-0.005 (0.011)	-0.000 (0.008)	0.007 (0.011)	-0.003 (0.002)	-0.001 (0.004)	-0.002 (0.002)	0.005 (0.003)
(2) Post BIC adoption: school with >25% coverage	-0.021 (0.014)	-0.005 (0.018)	-0.020* (0.009)	0.005 (0.017)	-0.006 (0.003)	-0.001 (0.004)	-0.005* (0.002)	0.008* (0.004)
(3) Post BIC adoption: full school	-0.041 (0.027)	0.028 (0.037)	-0.015 (0.019)	-0.008 (0.034)	-0.007 (0.009)	0.014 (0.010)	-0.005 (0.004)	0.012 (0.009)
Observations	717,486	744,934	1,097,593	1,126,258	717,486	744,934	1,097,593	1,126,258

Notes: Standard errors robust to clustering at the school level shown in parentheses (* $p<0.05$). All Models control for lagged z-score, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Excludes charter school students and students attending citywide special education schools (District 75).

Appendix Table 4: Impact of BIC on obesity and BMI – using percent of BIC classrooms treatment (compare to Table 3)

	Grades K-5 Pre-post		Grades 6-8 Pre-post		Grades K-5 Cumulative days		Grades 6-8 Cumulative days	
	Female	Male	Female	Male	Female	Male	Female	Male
Panel A: Impact on zBMI								
(1) Percent of classrooms	-0.017	-0.017	-0.061	-0.001	-0.000	-0.000	0.001	0.000
	(0.029)	(0.026)	(0.070)	(0.027)	(0.000)	(0.000)	(0.001)	(0.000)
Panel B: Impact on obesity								
(2) Percent of classrooms	-0.002	-0.004	-0.019	-0.005	-0.000	-0.000	0.000	0.000
	(0.009)	(0.008)	(0.0259)	(0.010)	(0.000)	(0.000)	(0.001)	(0.000)
Observations	1,058,212	1,071,311	487,154	490,503	1,058,212	1,071,311	487,154	490,503

Notes: Standard errors robust to clustering at the school level shown in parentheses (* p<0.05). Obese is defined as being above the 95th percentile nationally for one's gender and age in months, based on the 2000 CDC BMI-for-age charts. All models include student covariates, grade, school, and year effects. Covariates include age, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Age is measured in months at the time of the Fitnessgram measurements. We exclude charter school students, students attending citywide special education schools (District 75), students in schools where Fitnessgram coverage is less than 50 percent, and students with biologically implausible BMIs.

Appendix Table 5: Impact of BIC on ELA and math achievement – using percent of BIC classrooms treatment (compare to Table 4)

	Grades 4-5 Pre-post ELA	 Math	Grades 6-8 Pre-post ELA	 Math	Grades 4-5 Days this year ELA	 Math	Grades 6-8 Days this year ELA	 Math
(1) Percent of classrooms	-0.011 (0.008)	-0.001 (0.032)	-0.000 (0.008)	0.017 (0.021)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Observations	717,486	744,934	1,097,593	1,126,258	717,486	744,934	1,097,593	1,126,258

Notes: Standard errors robust to clustering at the school level shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1). All Models control for lagged z-score, race/ethnicity, low income status, LEP, immigrant, and special education status. Low income is measured by eligibility for free or reduced price meals or enrollment in a Universal Free Meal school. Excludes charter school students and students attending citywide special education schools (District 75).

Note: other results available for inclusion in the supplemental online appendix include the following (omitted here for length):

Appendix Tables 6a – 6c: sets BIC cumulative days to zero if the student's current school is not offering BIC
Appendix Tables 7a – 7c: redefines BIC treatment as cumulative days this year only; also includes a control variable equal to one if the student has previously been offered BIC
Appendix Tables 8a – 8c: redefines BIC treatment as cumulative days this year, where treated schools are only those who first offered BIC in 2010. Only data from 2010 is used.
Appendix Tables 9a – 9c: same as 3a – 3c, but data from 2007 – 2010 is used, and school effects are included in the models.
Appendix Tables 10a – 10c: original models from paper but using an identical sample of students across models.
Appendix Tables 11a – 11c: original models from paper but including mutually exclusive treatment intensities in the same regression (<25% BIC, >25% but not full school, full school).