CORBETT GRAINGER, BENJAMIN SENAUER, AND
C. FORD RUNGE

Nutritional Improvements and Student Food Choices in a School Lunch Program

This study analyzed data on students' food purchases linked to their school records to examine factors affecting the healthiness of their food choices and the impacts of reforms to promote healthier eating in a high school lunch program. U.S. Department of Agriculture's Healthy Eating Index was used to evaluate the nutritional quality of the foods purchased, as well as an alterative ranking developed by the school dietitian. The new lunch program was associated with an improvement in the nutritional quality of students' food choices. Girls tended to purchase relatively healthier food than boys, but male students had a greater improvement in the healthiness of their food choices.

Ninety-nine percent of U.S. public schools and 83% of public and private schools combined participate in the National School Lunch Program (NSLP). These schools receive cash subsidies and commodities from the U.S. Department of Agriculture (USDA) for each meal served. In return, they are supposed to satisfy USDA's nutritional requirements and provide free or reduced-price lunch to eligible children. During 2004–2005, the reimbursement rates for free, reduced-price, and paid lunches were $2.24, $1.84, and $0.21, respectively (USDA, Food and Nutrition Service [FNS] 2005b, 2005c). In 2004, U.S. schools served 4.8 billion lunch meals, reaching over 25 million children (Guthrie 2003; USDA, FNS 2005c). For many, especially students from lower-income families enrolled in federally subsidized free and reduced-price lunch programs, these are the main meals of the day. In addition to these federally subsidized meals, millions of

Corbett Grainger was an MS student in the Department of Applied Economics when this work was completed (grainger@econ.ucsb.edu). He is currently a PhD student in economics at the University of California, Santa Barbara, CA. Benjamin Senauer is a professor in the Department of Applied Economics and co-director of The Food Industry Center at the University of Minnesota, St. Paul, MN (bsenauer@umn.edu). C. Ford Runge is Distinguished McKnight University Professor of applied economics and law, and director of the Center for International Food and Agricultural Policy at the University of Minnesota, St. Paul, MN (frunge@umn.edu).

This research was supported by a grant from the McKnight Foundation. The authors thank Bertrand Weber and Michele Wignal for their assistance. They were the director and dietician for the Hopkins School Food Service at the time of this study.

The Journal of Consumer Affairs, Vol. 41, No. 2, 2007
ISSN 0022-0078

students choose foods from à la carte offerings provided by most school food services. These are not part of the NSLP and are referred to as "competitive foods" by USDA.

The American Obesity Association (2005) reported that 30.3% of children ages 6–19 were overweight or obese in 2000. This figure tripled from the early 1970s to 2000. Many factors are behind this trend, but there is evidence that meals served in many schools contributed to poor nutrition and obesity (Cooper and Holmes 2006). In a nationwide assessment, USDA found that the average lunch served in 1998–99 met its dietary guidelines of fewer than 30% of total calories from fat and less than 10% from saturated fat in only one out of seven secondary schools (USDA, FNS 2001). Many secondary students eat high-fat cheeseburgers, French fries, and pizzas on a daily basis. In some cases, they eat only a candy bar and a super-sized soft drink. Two reporters visiting six schools in New York City and Montgomery County, Maryland (an affluent Washington, DC, suburb), observed hundreds of students eating lunch and saw only five who took the green vegetable offered with the full meal (Becker and Burros 2003).

School food service directors often must focus on ease of preparation rather than healthy options because they lack both the skilled staff and facilities necessary to do more. Many schools depend on major food service vendors to supply highly processed foods that require little more than heating to prepare. Faced with tight budgets, food service operations are driven by cost considerations and a need to serve what students will eat. Major fast food chains' products are being served in a substantial number of schools, because that is what students want. School districts have also signed vending contracts with snack and soda companies for the commission generated to fund their programs. Schools have begun to be heavily criticized for not providing healthier food choices and guiding students toward healthy lifelong eating habits (Cooper and Holmes 2006; USDA, FNS 2001).

Recently, some school districts have taken steps to change their food programs. A 2005 USDA study, *Making It Happen! School Nutrition Success Stories*, reports on 32 schools and school districts that have made innovative changes to improve the nutritional quality of their food programs. The encouraging message from these case studies is that "students will buy and consume healthful foods and beverages, and schools can make money from healthful options" (USDA, FNS 2005a, executive summary). Hopkins School District 270 in Minnesota has been one of the innovators. Its food service program has improved the quality of food served, the variety of healthful choices available, and the school food service environment. Moreover, the Hopkins food service program demonstrated its financial

viability. The program is able to operate on a revenue-neutral basis, not requiring a subsidy from the school district (Royal Cuisine 2006). Because of these changes, Hopkins High School provided an opportunity to study the lunch choices of adolescents and how they might be changed.

In previous research using cross-sectional data, Akin, Guilkey, and Popkin (1983) found that students who participated in the NSLP had higher intakes of vitamins and minerals over a 24-hour period compared to nonparticipants and that the impact was stronger for low-income children. In a similar study, Gleason and Suitor (2003) examined the effect of NSLP participation on students' dietary intakes, also in comparison to nonparticipants. Using a fixed-effects model, the researchers found that NSLP participation had an improvement in the 24-hour intake of six vitamins and minerals. Participants consumed higher levels of fat but fewer added sugars than nonparticipants.

A relationship between childhood obesity and school feeding programs was established by Anderson and Butcher (2005), who linked the availability of snack foods and beverages in schools to adolescent obesity. They found that an association between schools with vending machine contracts and increased body mass index levels. The nutrition literature suggests that interventions to promote healthy eating can work. Studies typically focus on evaluating the impact of controlled interventions designed by the researchers that are implemented on a trial or temporary basis. For example, Perry et al. (2004) and French et al. (1997) assigned schools randomly to a control or an intervention group, in which interventions were successfully initiated to encourage fruit and vegetable consumption.

Simply offering nutritious foods does not necessarily improve students' diets, if the foods are not appealing. Students will avoid these choices or leave them uneaten. Ralston, Buzby, and Guthrie (2003) outlined strategies to increase the appeal of school lunches and breakfasts, suggesting that schools expand the offerings available, allow student input in food service decisions, improve the selection of USDA commodities, increase the use of fresh produce and local foods, and improve methods of preparation. Beyond the food itself, the school lunchroom is frequently chaotic and students must rush to eat in the very short time allotted.

With access to a unique data set, we examined the school lunch choices over three years (2002–2005) in Hopkins High School, located in a western suburb of Minneapolis, and the impact of the food service changes on measures of nutritional quality. Students at Hopkins use debit accounts and personal identification numbers to purchase food. This point-of-sale (POS) data allowed students to be linked with their purchases on the cash registrar records and with their demographic and other information through their

school records. USDA's Healthy Eating Index (HEI) was used to evaluate the nutritional quality of the specific food items offered. An alternative nutritional ranking developed by the school dietitian was also utilized, for reasons explained below. This approach provided a measure of the overall healthiness of foods purchased for lunch by a student over a 10-day period. Econometric methods were then used to examine factors affecting a student's food choices and whether they changed after the program innovations.

To our knowledge, this is the first study to use POS data linked to students' records to examine the factors affecting the healthiness of students' food choices and the impacts of comprehensive reforms to promote healthier eating in a school lunch program.

Although it is a case study of changes in one school's food service operations, Hopkins is in many respects a typical suburban school district. Lessons for many other schools nationwide might be drawn from its food service reforms.

THE HOPKINS FOOD PROGRAM

The food service program in the Hopkins School District underwent dramatic changes after 2003. Hopkins is typical of many older, inner-ring suburbs in major American metropolitan areas and is not particularly wealthy. Most of its students come from middle rather than upper-income households, and there are an increasing number of minority students and lower-income families. Hopkins food service was also typical in providing à la carte foods in addition to the NSLP lunches, as do 80% of schools nationally (CDC 2000). Until 2003, foods in the main cafeteria line were easy-to-prepare and à la carte items, included pizza from Pizza Hut and Domino's, cheeseburgers, chips, and high-calorie beverages. All foods were served on disposable trays. Vending operations were contracted out and machines were stocked with soda, candy, and potato chips. By the end of school year 2002, the district superintendent, with the support of the school board, set goals of providing quality foods in an appealing environment in the district's cafeterias, which serve a total of about 9,000 students daily. To implement a new program, in July 2003, the district hired a new food service director who had a professional restaurant and hotel food service management background.

The innovations began at the high school, opening an optional window called the Health Nut Café, which served only foods free of *trans*-fats, high in fiber with low levels of sugars, including high-fructose corn syrup. The offerings included organic whole-grain cookies, 100% juice drinks, and

freshly made salads and sandwiches. Later that year, the vending contract with Pepsi was canceled, which had been a lucrative source of unrestricted cash. Rather than eliminating the machines, the Hopkins Schools bought them, filling them with water and 100% juices. After the voters approved a bonding initiative, a new food service kitchen and lunchroom area were built at the high school. The new program, named Royal Cuisine, dramatically changed food service operations in all schools in the district, although the most profound changes were visible at Hopkins High School.

The new program focused on preparing more nutritious foods on site. No longer were meals simply warmed prior to service; cooking from scratch became the norm and students ate from plates with flatware. In the high school, in addition to the Health Nut Café, a new food service window, the Diner, offered full meals beginning in 2003–2004. In 2004–2005, the Tuscan Oven and Ethnic Adventures, both of which are NSLP meal options, were introduced in the high school cafeteria. Starting in fall 2004, the switch was made to low-fat salad dressings and cheese (including pizzas) and whole-wheat breads and pizza crusts. In addition, more vegetables were added to many dishes, including the pizza toppings.

Because preparing foods from scratch and providing more fresh fruits and vegetables is more expensive, prices increased. The price at Hopkins of the NSLP meal was $2.05 in 2002–2003, $2.30 in 2003–2003, and $2.50 in 2004–2005. The food service director's experience in the private sector led him to focus on increasing efficiency and productivity in the kitchens to keep costs down. Although the capital expenditure required to start such a program was large, variable costs such as labor did not increase substantially due to efficiency gains. Hopkins had a "closed-campus" policy, which means that students could not go off campus to buy food and the school food service did not have to compete against fast food outlets and others. Nationally, 94% of elementary schools and 72% of high schools have closed campuses (CDC, National Center for Chronic Disease Prevention and Health Promotion, Division of Adolescent and School Health 2006).

METHODS

Each student in the Hopkins School District had a personal spending account with an associated personal identification number used for purchasing food. Students and their families deposited money into their accounts on a rolling basis. On any given day, a student purchasing food items in the school entered his or her personal identification number at the point of purchase and a cashier entered the item numbers of the foods chosen. Sales

data were then kept electronically. The data used in this analysis can be grouped into four main categories: sales, expenditure, student demographic data, and nutritional ratings.

Sales Data

Sales data came from the Hopkins food service program. POS reports were run for a random sample of students using their personal identification numbers for November 2002, 2003, and 2004 as well as April 2003, 2004, and 2005. Because of the demands on the school district staffs' time to assemble the data, we were only able to obtain data for a sample of students, who were sophomores in 2002–2003, juniors in 2003–2004, and seniors in 2004–2005. Since the major changes implemented in Hopkins came after the new food service director started in July, 2003, the school year 2002–2003 was treated as a baseline.

Daily data on the item number and the quantity purchased by each student were provided in the POS report. The item number corresponded to the food purchased for some items and represented a food category in other cases. For example, item number 647 was a hot dog, but item number 643 represented "$2.00 miscellaneous," a category designed to capture all items costing $2.00 that did not have a separate key on the cash register. For this reason, it was not possible to determine what item was purchased if 643 appeared in the POS report for a student. The cash registers had a limited number of keys, and minimizing the number of key strokes speeded up the checkout process. However, most item numbers corresponded to a unique food product, providing a rich data set of historical à la carte purchases.

The full NSLP meals also appeared in the POS reports. However, only for academic year 2004–2005 was it possible to distinguish which entrée the student purchased. The side items that supplement the entrée to create a full NSLP meal did not appear in the data since they were not keyed in by the cashier. In the first two years (i.e., 2002–2003 and 2003–2004), the data indicated whether the student purchased an NSLP lunch but not which one.

Expenditure

NSLP meal and à la carte item prices were obtained from the food service and entered into a database. In the analysis to follow, "expenditure" refers to the total value of the foods purchased by a given student for the specified time frame. Students receiving free or reduced-price lunches paid less than the expenditure shown. In these cases, expenditures correspond to the total value of the foods purchased.

Demographic Data

Demographic data for each student were also gathered. With the cooperation of the school district office, access to student demographic data was granted. Using only the student's ID number to preserve privacy, students' purchases were matched to his or her demographic characteristics. Table 1 summarizes the demographic variables by month and year, together with the number of observations in each category.

Female and male dummy variables (with the latter omitted) were used in the statistical analysis. With cohort data, age or grade was not a variable in a given year since the students were all sophomores in 2002–2003, juniors in 2003–2004, and seniors in 2004–2005. For each student, the school district held data regarding ethnicity/race. Ethnicity/race was divided into five groups: white (omitted), Asian, black, Hispanic, and American Indian/Alaskan/Pacific Islander, which we term other for the sake of brevity. These were used as indicator variables.

Finally, the district provided data on the federal assistance each student received for school lunch through the NSLP, that is, if the student received a free or reduced-price lunch. These were combined to create the low-income indicator variable. This served both as an indication of the subsidy received per student and as a proxy for that family's household income, on which eligibility for free or reduced-price meals was based. An average of 6.9% of the students across the six time periods received free or reduced-price NSLP lunches. Nationwide, 9.8% of NSLP participants received free or reduced-price meals in 2003, 9.9% in 2004, and 10.0% in 2005 (U.S. Census Bureau 2007). Hopkins High School is thus somewhat lower than the national average.

TABLE 1
Demographic Data Summary for Hopkins High School Students

	November 2002	April 2003	November 2003	April 2004	November 2004	April 2005
Sample size	515	561	566	555	523	480
Female	254	274	283	280	250	233
Male	261	287	283	275	273	247
Indian	6	6	6	4	3	2
Asian	26	28	24	27	27	26
Hispanic	17	16	11	13	16	16
Black	33	32	51	47	34	34
White	433	479	474	464	443	402
Reduced	11	12	13	14	15	9
Free	22	17	33	22	26	28

Note: The demographic data cover students from Hopkins High School in Hopkins, MN. These samples were randomly drawn for each month and year combination.

Nutritional Ratings and Relative Healthiness Index

The fourth type of data concerned nutritional ratings of the foods purchased. For this measure, we constructed two indexes of the healthiness of student food choices. The first relative healthiness index (RHI) was based on the ratings of the school dietitian, and referred to as the "dietitian-developed index" (RHI-DDI). The second ranked foods using the USDA's HEI (RHI-HEI). The two indexes are described below.

RHI-DDI

One of the key dependent variables was developed in conjunction with the school district's dietitian/nutritionist. This index was constructed by considering every à la carte item in each of the three years and every NSLP lunch entrée in the 2004–2005 school year. Each item was rated "more healthy" and given a rating of +1, "less healthy" (−1), or not clearly either (0), based on the nutritional content of the foods. The dietitian worked in the high school over the entire time period and used a computerized nutritional menu planner, so was able to verify the nutritional content ratings. As discussed in the sales section, because each entŕee could be paired with multiple side items, we considered the entrée's rating only in the case of the NSLP meals.

Since the data covered food purchases, what the students actually consumed was not known with certainty. However, in multiple visits to the school district lunchrooms, the authors observed very little food being thrown out. The food service staff confirmed this observation. Because students had a wide range of choices, even for the full NSLP meals, they satisfied their food preferences and had relatively little plate waste.

Both positive and negative criteria were used to rank foods. Positive factors included whether the food was made with whole grains, contained multiple fruits and vegetables, and was minimally processed. Negative factors included *trans*-fatty acids content, high other fats content, and high levels of sugars including high-fructose corn syrup. In general, foods rated healthier were lower in fat and had more nutrients per calorie, whereas less healthful foods were higher in fat, more energy dense, and had relatively low nutrient value. These ratings were then tied to the item numbers from the sales data.

To provide a feel for how the index worked, consider some food items that were given a healthier rating of +1: milk (1/2 pint), yogurt (4 oz.), vegetables with dip, fresh fruit, and a mixed salad. Items rated a −1 included ice cream, milk shakes, cinnamon rolls, chocolate chip cookies, and shrimp

poppers. Examples of foods given a neutral rating included a super pretzel, coffee, apple cider, an English muffin, and a ham and cheese sandwich.

Once each food was ranked, the RHI-DDI was constructed. For each day in each month, the average rating of the items purchased by a student was calculated and defined as the "daily average rating" for student *i*. To smooth out day-to-day fluctuations in choices, a measure was needed that included multiple days in a given month. For each month, the 10-day sum of these "daily average ratings" was calculated for each student, over the first 10 days of a student's purchases.[1] This sum is the RHI-DDI, which ranged from –10 to +10. In one specification, this included only à la carte items; in the specification for the 2004–2005 school year, it included NSLP meal entrées and à la carte items. To differentiate between the two specifications, we denoted the latter as $\text{RHI-DDI}_{\text{meal}}$.

It is important to note that the actual observed days for each student may vary because to constrain this measure to the same days for all students would result in a drastic reduction in sample size. Although the RHI-DDI used the first 10 days in each month in which students purchased food, à la carte choices available on any day of the month did not change, so that the choices on any given day varied only in the entrée selection. All à la carte items as well as grill, deli, and salad options were consistently offered over each time period, although the food service steadily improved the quality of foods offered. It is important to emphasize that while the food offerings generally became more healthful over time, there were still foods available at the high school with very low nutritional ratings in 2004–2005. Students were not forced to choose healthier foods simply because less healthy choices were eliminated.

Because the RHI-DDI score provided by school district's dietitian may be open to challenge, its validity was checked by using an alternative measure based solely on the nutritional components of the foods developed by USDA. We employed both specifications when possible, but when considering NSLP meals, the RHI-DDI was used because of data limitations.

RHI-HEI

For this measure, we used the 12 components from the USDA's HEI to rate each food on a 0–100 scale, based on the nutritional content of the

1. The choice of 10 days was somewhat arbitrary—summing over five days did not create as much variation in the constructed dependent variable as 10 days, and more than 10 days reduced the number of students considered each month considerably. The same analyses were conducted using different time periods, and the number of days did not affect the results significantly.

foods (USDA, CNPP 2005; see the appendix). The HEI was used to give a score to a person's lunch diet, but because information on what students were eating outside the school was unavailable, the HEI could not rate a student's total diet as traditionally done (for an example of its traditional use, see Bowman, Gerrior, and Basiotis 1998, and Variyam, Blaylock, and Smallwood 1998). Given the detailed data on à la carte purchases, these foods could be rated using the HEI. Information available on the NSLP entrées in 2004–2005 allowed only the RHI-DDI to be used.

Each à la carte item was given a score based on the 12 components of the HEI. If an item met the standard, it was given full points for that category. For example, a serving of pure orange juice was given 5 points for the fruit category, 0 points for the whole fruit category (because it is a juice), 0 for most other categories, but 10 points for low sodium and saturated fat and 20 points for calories, for a total of 45 points. Every à la carte item received an HEI score. Scoring criteria are outlined in the appendix.

After rating each food, the RHI-HEI was constructed. For each day in each month, the average rating of the à la carte items purchased by a student was calculated as the "daily average rating" for student *i*. For each month, the 10-day average of these "daily average ratings" was calculated for the first 10 days the student made à la carte purchases. This 10-day average is the RHI-HEI utilized.

Descriptive statistics by month are shown in Table 2. Both indexes clearly trend upward on average over time, showing that students were making healthier food choices. In November 2002, the average RHI-DDI was –1.237, which improved to 2.571 by April 2005. Likewise, the mean RHI-HEI increased from 23.062 to 27.656. Both indexes fell in April 2004 without explanation. The minimum RHI-DDI in each time period was –10 suggesting substantial variation in student eating behavior, including continued purchases of less healthy food. For three periods, the maximum value was 10, again supporting a wide range of behavior. The minimum RHI-HEI was less than 10 in every month and as low as 0.75 in April 2004. The maximum was 45 or more in three of the months. The correlation between the two indexes across all months was 0.6554, indicating that RHI-DDI was a reasonable measure of the healthiness of a students' food choices.

Given the grade cohort sample, it is possible that improvements in nutrition could be related to increases in age and maturity. However, USDA research showed that the nutritional quality of children's and adolescents' diets deteriorates as they grow older (Devaney, Gordon, and Burghardt 1993). The steady improvement in the RHIs in Table 2, rather than a sharp improvement between 2002–2003 (prior to the new program) and

TABLE 2
Descriptive Statistics for the RHIs for À La Carte Foods

	November 2002	April 2003	November 2003	April 2004	November 2004	April 2005
RHI-DDI						
Mean	−1.237	−0.791	0.559	0.469	1.930	2.571
SD	2.883	3.154	3.568	3.317	3.779	3.681
Min	−10	−10	−10	−10	−10	−10
Max	8.5	9.17	10	9.5	10	10
RHI-HEI						
Mean	23.062	23.303	24.166	19.976	27.807	27.656
SD	4.551	4.666	6.082	6.009	6.697	6.259
Min	8.5	8.458	9.417	0.75	6.5	3.5
Max	40.8	43.708	45	33.833	45.25	45
n	334	349	324	313	283	257

Note: The RHI is a measure of the healthiness of a student's à la carte choices over a 10-day period. The description of its construction is discussed in detail in the data section. RHI-HEI is based on the criteria used in the USDA's HEI and RHI-DDI is based on the school-dietitian-developed index. Min and Max refer to the minimum and maximum observed value of RHI, respectively. The possible range for RHI-DDI is −10 to +10 and for RHI-HEI is from 0 to 100. However, given the construction of RHI-HEI and the food components evaluated, it would be very unlikely to have an actual food item with an RHI-HEI greater than 45–50. The sample includes all students who purchased à la carte items on at least 10 days during the given month.

2003–2004 (after the new program commenced), should not be surprising given that the changes in food service operations were introduced gradually.

Econometric Methodology

As noted above, for each month/year combination, repeated random samples were drawn from the same cohort of students who were sophomores in 2002–2003, juniors in 2003–2004, and seniors in 2004–2005. Hence, the number of observations for each student varies by individual and forms an unbalanced panel. Although desirable methodologically, sufficient research funding was not available to identify and then obtain and analyze data from a "control" school, in which the food program remained unchanged during this period. The RHI-DDI and RHI-HEI were calculated only for students purchasing one or more à la carte items on at least 10 days during a given month, and the first 10 days for each student were used in the calculation. Data contained entries for each of the six months under consideration, with 550 individuals appearing at least once, and the average student observed in 4.3 time periods.

The central research question is whether the improvements in the school lunch offerings had an effect on the overall nutritional quality of the

students' lunch choices. In addition, how did factors such as gender, ethnicity/race, and expenditure affect the healthiness of students' school lunch choices? Finally, did different groups of students, such as males and females, respond differently to the lunch program changes? To answer these questions, the two measures of RHI were used as the dependent variables in a series of regressions.

The regression equation specified was:

$$\mathrm{RHI}_{it} = \alpha + x'_{it}\beta + \gamma \mathrm{Trend}_t + u_i + \varepsilon_{it} \quad (1)$$

where x_{it} is a vector of demographic characteristics of student i in period t, and Trend_t is a variable that assigns a value of 1 to the first month of the analysis (November 2002), a 2 to the second, 3 to the third, and so on, to test whether there was a constant (linear) improvement in RHI over time. We also included multiplicative interaction terms, trend × Asian, trend × black, trend × Indian, trend × Hispanic, and trend × male. These tested for trends for each of the respective demographic groups in terms of eating healthier foods. In an alternative specification (not reported here), we included month dummies rather than the trend variable and interactions. The results using that model were very similar to those reported below and are available from the authors upon request.

Equation (1) was estimated under two sets of assumptions. First, we assumed that u_i is uncorrelated with the explanatory variables. This is the random-effects specification. We also estimated equation (1) assuming that u_i can be arbitrarily correlated with the explanatory variables (i.e., it is a student-specific fixed effect). In the case of student-specific fixed effects, time-invariant explanatory variables are excluded from the estimation (Wooldridge 2002). Equation (1) was estimated under both sets of assumptions using Stata 8.1.

Ninety-six students were observed in just one month, which in the fixed-effects model is equivalent to running the regression for the panel without these observations. If the random-effects assumptions are valid, these observations could still be used in the estimation. The panel was unbalanced due to randomly sampling individuals each month, so these students were unlikely to be different from those who appear more often. As a check on the specifications presented, regressions were run omitting students with fewer than three months of observations and results did not change significantly. The sample was also restricted to create a balanced panel and we again found that results did not change substantially.

EMPIRICAL RESULTS

Table 3 presents results for the two indexes of relative healthiness for à la carte purchases over the six month/year periods. For RHI-HEI, results for the random- and fixed-effects models of equation (1) are shown in columns 1 and 2. For the RHI-DDI, results for the random- and fixed-effects models are shown in columns 3 and 4. R^2 are low, which is not unusual in the analysis of individual consumer behavior. Lower R^2 with fixed effects are also expected. To test for the presence of random effects, the Hausman test was performed by comparing each pair of estimates (i.e., columns 1 and 2, and columns 3 and 4) (Hausman 1978). The test for the regressions using RHI-HEI (columns 1 and 2) in Table 3 did not reject random effects (p value = .5003), nor did the test reject random effects when comparing the results of the RHI-DDI regressions in columns 3 and 4 (p value = .1034). Since the random-effects specifications allowed us to examine the role of time-invariant demographic variables, discussion is focused on these results.

Results summarized in Table 3 show that expenditure (the amount spent by a student over the 10-day period) was positively correlated with RHI in the random-effects regression in all specifications, plus in the fixed-effects regression using RHI-HEI in column 2. This was expected since more healthful foods were generally more expensive. The coefficient for female was positive and significant in both random-effects specifications; females were more likely to make healthier food choices than white males, the omitted group reflected in the intercept. This finding is consistent with previous studies tying gender to healthy eating (USDHHS 2000). In terms of the ethnicity/race variables, Asians made healthier food choices than white males. In column 1, the variable black had a negative effect, but was significant only at the 10% level and not significant in column 3. Low income, reflecting whether students received a free or reduced-price NSLP meal, also did not have a significant effect. This result was encouraging because it means that poorer students, who receive assistance buying lunch, were able to make food choices that are as healthy as other students.

The linear time trend variable (trend) was positive and significant at the 1% level in every specification in Table 3. This provides clear support for the hypothesis that there was an improvement in students' diets over time and that these improvements were associated with the changes implemented by the school district. However, trend might also reflect other factors changing over the period.

In both random-effects equations, the coefficient for Asian was positive and significant as noted, while the interaction variable trend × Asian was negative and significant. This combination suggests that although Asians

TABLE 3
RHI Regression Results for À La Carte Foods for 2002–2005

Dependent Variable	Random Effects, RHI-HEI	Fixed Effects, RHI-HEI	Random Effects, RHI-DDI	Fixed Effects, RHI-DDI
Expenditure	0.05840 (.01090)***	0.04246 (.01507)***	0.02252 (.00579)***	0.00867 (.00724)
Female	3.95769 (.64318)***	—	2.13771 (.34937)***	—
Asian	3.12371 (1.59618)**	—	1.68108 (.86480)*	—
Black	−3.03510 (1.80164)*	—	−1.41100 (.95381)	—
Hispanic	2.40425 (2.15368)	—	1.87835 (1.16891)	—
Other	−2.17893 (3.56607)	—	0.48096 (1.93920)	—
Low income	−1.21654 (2.15294)	1.90922 (4.22034)	0.35664 (1.15515)	1.84900 (2.02705)
Trend	0.66077 (.11623)***	0.61460 (.12903)***	0.69286 (.05789)***	0.66417 (.06197)***
Trend × male	0.65722 (.15577)***	0.57164 (.17135)***	0.30392 (.07738)***	0.27010 (.08230)***
Trend × Asian	−0.96956 (.37003)***	−0.98694 (.41363)**	−0.50828 (.18425)***	−0.53342 (.19867)***
Trend × black	0.46913 (0.45109)	0.87531 (0.53273)*	0.34966 (0.22771)	0.31546 (0.25587)
Trend × Hispanic	−0.60228 (0.49517)	−0.46348 (0.55653)	−0.60028 (0.24654)**	−0.58525 (0.26730)**
Trend × Indian	0.77030 (0.94695)	0.90439 (1.00868)	−0.04340 (0.46756)	0.09130 (0.48447)
Trend × low income	0.36840 (0.60069)	−0.53841 (0.89081)	−0.39613 (0.31687)	−0.70142 (0.42786)
Intercept	17.08412 (0.66227)***	19.83373 (0.68597)***	−4.14117 (0.35462)***	−2.40320 (0.32948)***
Rho	0.26393	0.48705	0.44255	0.58891
Wald χ^2, $F(9, 1301)$	181.41	12.19	454.75	40.13
R^2 within	0.0764	0.0778	0.2147	0.2173
R^2 between	0.1195	0.0057	0.1635	0.0363
R^2 overall	0.0997	0.0212	0.1738	0.0841
N	1,860	1,860	1,860	1,860

Note: The *RHI* is a measure of the healthiness of a student's à la carte choices over a 10-day period. The description of its construction is discussed in detail in the data section. RHI-HEI is based on the criteria used in the USDA's HEI and RHI-DDI is based on the school-dietitian-developed index. SEs are given in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Recall this is an unbalanced panel; there are 1,860 total observations and 550 students, with observations every November and April from November 2002 to April 2005. The Hausman test p values are .5003 and .102, respectively.

might have made healthier choices than whites, the improvement in RHI for Asian students was less dramatic. The variable trend × Hispanic was also negative and significant in both the fixed- and random-effects estimations using RHI-DDI but not significant using RHI-HEI as a dependent variable. This result suggests that Hispanics improved less than other groups but was not robust across dependent variables. It is important to stress that these interaction variables do not imply that minority students experienced a decline in their RHI scores; rather, because trend was positive, it suggests that the healthiness of their choices improved less dramatically than that of white students.

The interaction term trend × male was positive and significant at the 1% level across specifications, implying that males had a greater improvement in the healthiness of their choices than females over the period (not that females saw a decrease in RHI). Recall that female was positive and significant in both equations. This means that males improved their RHI scores at a greater rate than females. Getting teenage males to eat healthier food is known to be particularly difficult. Therefore, it is encouraging that males saw an improvement in the healthiness of their food choices after the innovations in the school feeding program.

Recall that RHI-DDI_{meal} was calculated only for 2004–2005 due to data restrictions. During 2004–2005, the entrée purchased with a full NSLP meal was captured in the data and could be rated by the dietitian for healthiness. For this reason, we estimated this year separately, constructing the dependent variable for student i if he or she purchased at least two à la carte items or an NSLP meal on at least 10 days during that month. As before, if the student met these criteria, the student's first 10 days with such purchases were used. Because the data only cover two months in this specification, we included only students who were observed in both periods. There were 292 students in this sample for a total of 584 observations in November and April.

Table 4 presents the results for the random- and fixed-effects estimates for 2004–2005. Interaction terms with the "trend" variable were not included because the time period considered was only two months, and no food service changes were implemented between November and April. As seen in Table 4, by including full NSLP meals in the calculation, the previous positive relationship between expenditure and RHI no longer held. The full NSLP meals during the 2004–2005 academic year generally received high healthiness ratings and meals were a relatively inexpensive alternative to à la carte lunches.

Interestingly, female was not significant in the random-effects regression in column 1. Given the negative and significant coefficients, black and

TABLE 4
RHI Regression Results for À La Carte Foods and NSLP Meal Entrées for 2004–2005 (Dependent Variable: RHI-DDImeal)

	Random Effects	Fixed Effects
Expenditure	−0.00549 (0.01501)	−0.00118 (.02432)
Female	0.30702 (0.39305)	—
Asian	−0.78645 (−0.78646)	—
Black	−2.01814 (0.73864)***	—
Hispanic	−1.0577 (1.10863)	—
Other	−7.3618 (2.3350)***	—
Reduced	0.68893 (1.40198)	—
Free	−0.178034 (0.72800)	—
November 2004 dummy	−1.57706 (0.22544)***	−1.56903 (0.22725)***
Intercept	4.88328 (0.70143)***	4.45346 (0.98544)***
Rho	0.70143	0.60053
Wald χ^2, $F(2, 290)$	73.68	24.22
R^2 within	0.1430	0.1431
R^2 between	0.0815	0.0037
R^2 overall	0.0987	0.0410
N	584	584

Note: The *RHI* is a measure of the healthiness of a student's à la carte and NSLP meal entrée choices over a 10-day period. The sample includes observations for November 2004 and April 2005. The description of its construction is discussed in detail in the data section. For 2004–2005, RHI is based on the school-dietitian-developed index only. SEs are given in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Rho is the fraction of variance that is due to u_i, the individual disturbance term. There are 584 total observations, and the panel is restricted to students with observations in both periods.

especially other (i.e., Native American) students made substantially less healthy food choices than white males (the omitted group). This suggests that the food service needed to give particular attention to getting these groups to eat healthier foods. Receiving a reduced-price or free meal did not affect the healthiness of the students' school lunches, which is important to note. Since the November dummy variable was negative and significant, the improvement in the overall healthiness of the school lunches chosen continued over the 2004–2005 school year. Again, this effect could be reflecting other factors that changed between November 2004 and April 2005.

The food service found it necessary to raise prices of NSLP meals. These might have adversely affected participation. Therefore, tests were made to determine whether there was a statistically significant change in the participation rate for full NSLP lunches. Food service records indicated that participation actually increased over the three years. Paired *t*-tests comparing participation in November 2002, November 2003, and November 2004 rejected the null hypothesis that there had been no increase in participation,

with *p* values near zero. Similarly, tests for participation in April 2003 versus April 2004 and April 2005 were significant at the 5% level. There is strong statistical evidence that NSLP meal participation increased with implementation of the innovative program.

Not only did participation increase but also the average expenditure (the total value of all foods purchased) decreased over the time period. Even if the price of full NSLP meals increased, average expenditure would have decreased if more students bought meals and fewer students purchased multiple and/or expensive à la carte items. Mean daily expenditures of students making at least one purchase during the month were measured. Using Welch's approximation (Welch 1938, 1947) for the *t*-test, we tested the null hypothesis that the mean daily expenditure had not changed versus the alternative that it decreased. We tested November 2002 versus November 2004, as well as April 2003 with April 2005. Test statistics followed a *t*-distribution approximately with 792 and 851 df and were 152.52 and 130.95, respectively. Both had *p* values of .0000, suggesting clear rejection of the null hypothesis. Even though NSLP meal prices had increased, student expenditures on lunch actually declined.

Finally, food service staff also reported that there was no increase in students bringing food from home to avoid the new food choices. School food service managers reported that bringing food from home is not "cool." For an age group so sensitive to peer pressure, this factor may be very important.

CONCLUSIONS

Promoting healthier eating habits in schools is a major issue across the United States. However, rigorous analysis of the factors that determine whether student behavior can change has been limited. Casual empiricism or isolated and time-limited interventions cannot substitute for careful observation in a cafeteria in real life and real time. This study analyzed students' food choices in an actual high school cafeteria against a backdrop of major changes in its food program. A focus of the analysis was whether students made healthier food choices after the innovative program was introduced. The insights gained suggest approaches to bringing about improvements in school lunch programs elsewhere.

Hopkins School District dramatically revamped its school food program with a commitment to providing healthy and appealing food choices to students. As the new program was gradually introduced, there was a steady improvement in the nutritional quality of students' food choices. Moreover, the trend toward choosing healthier à la carte food choices strengthened the

longer the program operated. When both à la carte and full meals were analyzed together, students were clearly making healthier food choices in April 2005 than in November 2004. This suggests that over time, students will develop healthier eating habits if given a choice of appealing nutritious foods, at least on a closed campus. The argument that schools have to serve foods, such as processed pizzas and deep-fried French fries, or face dissatisfied students is unsupported. Without a control group, causality cannot be claimed definitively but an association between the food service reforms and the relative healthiness of students' food choices can be inferred.

Helping students develop healthier eating habits at school can be a key part of the fight against childhood obesity and potentially help improve lifelong health. The Hopkins food service reforms were associated with an improvement in the nutritional quality of students' food choices, while operating on a financially sound basis. Hopkins is a typical, older, inner-ring suburb with an increasingly diverse middle- and lower-income population. Its innovations can therefore serve as a model for reforms in many school districts nationwide.

Admittedly, these results for one school district, and the lack of a control group in another high school, are less than conclusive. Further, only limited information was available on NSLP meals. Researchers might conduct similar studies using POS data from school lunchroom cash registers, including a control group. Nevertheless, the innovations we have studied offer useful lessons for improving school food service operations.

APPENDIX

HEI Criteria Used in Constructing RHI-HEI

Component	Points	Standard for Points
Total fruit (includes 100% juice)	5	At least one serving
Whole fruit (not juice)	5	At least one serving
Vegetables	5	At least one serving
Dark green and orange vegetables/legumes	5	At least one serving
Total grains	5	At least one serving
Whole grains	5	At least one serving
Milk products	10	At least one serving
Meat and beans	10	At least one serving
Oils	10	$\geq$12 g per 1,000 kcal
Saturated fat	10	Constitutes $\leq$7% of calories
Sodium	10	$\leq$0.7 g per 1,000 calories
Calories from solid fat and added sugar	20	$\leq$20% of total calories

Note: This is an adapted version of the HEI, 2005 criteria (USDA, CNPP 2005). Each à la carte item was rated based on the components in the table above. Points were given if the à la carte item met the corresponding standard; otherwise the item received zero points.

REFERENCES

Akin, John S., David K. Guilkey, and Barry M. Popkin. 1983. The School Lunch Program and Nutritional Intake: A Switching Regression Analysis. *American Journal of Agricultural Economics*, 65 (3): 477–485.

American Obesity Association. 2005. *AOA Fact Sheets—Obesity in Youth*. http://www.obesity.org/subs/fastfacts/obesity-youth.shtml.

Anderson, Patricia M. and Kristin Butcher. 2005. *Reading, Writing and Raisinets: Are School Finances Contributing to Children's Obesity? National Bureau of Economic Research*. Working Paper 11177. http://www.nber.org/papers/w11177.

Becker, Elizabeth and Marian Burros. 2003. Eat Your Vegetables? Only at a Few Schools. *The New York Times*, January 13.

Bowman, Shanthy, Mark Lino, Shirley Gerrior, and P. Peter Basiotis. 1998. *The Healthy Eating Index: 1994–96*. Washington, DC: Center for Nutrition Policy and Promotion, U.S. Department of Agriculture. CNPP-5.

Centers for Disease Control and Prevention (CDC), National Center for Chronic Disease Prevention and Health Promotion, Division of Adolescent and School Health. 2006. *Fact Sheet: Foods and Beverages Sold Outside of the School Meal Programs, 2000*. http://www.cdc.gov/HealthyYouth/shpps/factsheets/pdf/outside_food.pdf.

Cooper, Ann and Lisa M. Holmes. 2006. *Lunch Lessons: Changing the Way We Feed Our Children*. New York: Collins.

Devaney, Barbara, Anne Gordon, and John Burghardt. 1993. *The School Nutrition Dietary Assessment: Dietary Intakes and Program Participants and Nonparticipants*. Washington, DC: Food and Nutrition Service, Office of Analysis and Evaluation, U.S. Department of Agriculture.

Gleason, Philip M. and Carol W. Suitor. 2003. Eating at School: How the National School Lunch Program Affects Children's Diets. *American Journal of Agricultural Economics*, 85 (4): 1047–1061.

Guthrie, Joanne. 2003. *A Healthy School Meal Environment. Food Assistance and Nutrition Research Report Number 34-6*. Washington, DC: U.S. Department of Agriculture.

Hausman, James. 1978. Specification Tests in Econometrics. *Econometrica*, 46 (6): 1251–1271.

Perry, Cheryl L., Donald B. Bishop, Gretchen L. Taylor, Marsha Davis, Mary Story, Clifton Gray, Susan C. Bishop, Rita A. Warren Mays, Leslie A. Lytle, and Lisa Harnack. 2004. A Randomized School Trial of Environmental Strategies to Encourage Fruit and Vegetable Consumption among Children. *Health Education and Behavior*, 31 (1): 65–76.

Ralston, Katherine, Jean Buzby, and Joanne Guthrie. 2003. *A Healthy School Meal Environment. Food Assistance and Nutrition Research Report Number 34-5*. Washington, DC: U.S. Department of Agriculture.

Royal Cuisine. 2006. *Royal Cuisine Business Plan: School Year 2006-07*. Hopkins, MN: Hopkins School District.

Simone French, Mary Story, Robert Jeffery, Patricia Synder, Marla Eisenberg, Abbey Sidebottom, and David Murray. 1997. Pricing Strategy to Promote Fruit and Vegetable Purchases in High School Cafeterias. *Journal of the American Dietetic Association*, 97 (9): 1008–1010.

U.S. Bureau of the Census. 2007. Statistical Abstract of the United States, 2007. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture (USDA), Center for Nutrition Policy and Promotion (CNPP). 2005. *The Healthy Eating Index, 2005*. CNPP Fact Sheet No. 1. Washington, DC: U.S. Department of Agriculture.

U.S. Department of Agriculture (USDA), Food and Nutrition Service (FNS). 2001. *School Nutrition Dietary Assessment Study II, Report No. CN-01SNDAII*. Washington DC: U.S. Department of Agriculture.

———. 2005a. *Making It Happen! School Nutrition Success Stories*, Washington, DC. http://www.fns.usda.gov/cnd/lunch/aboutlunch\nslpfactsheet.pdf.

———. 2005b. *Healthy Schools*, Washington, D.C. http://www.fns.usda.gov/tn/Healthy/wellness_policyrequirements.html

———. 2005c. *National School Annual Summary*. Washington, DC. http://www.fns.usda.gov/pd/slsummar.htm

U.S. Department of Health and Human Services (USDHHS). 2000. *Healthy People 2010*. Washington, DC: U.S. Department of Health and Human Services.

Variyam, Jayachandran N., James Blaylock, and David Smallwood. 1998. *USDA's Healthy Eating Index and Nutrition Information*. Technical Bulletin No. 1866. Washington, DC: U.S. Department of Agriculture.

Welch, Bernard L. 1938. The Significance of the Difference between Two Means When the Population Variances Are Unequal. *Biometrica*, 29 (3–4): 350–362.

——— 1947. The Generalization of "Student's" Problem When Several Different Population Variances Are Unknown. *Biometrica*, 29 (1–2): 28–35.

Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.